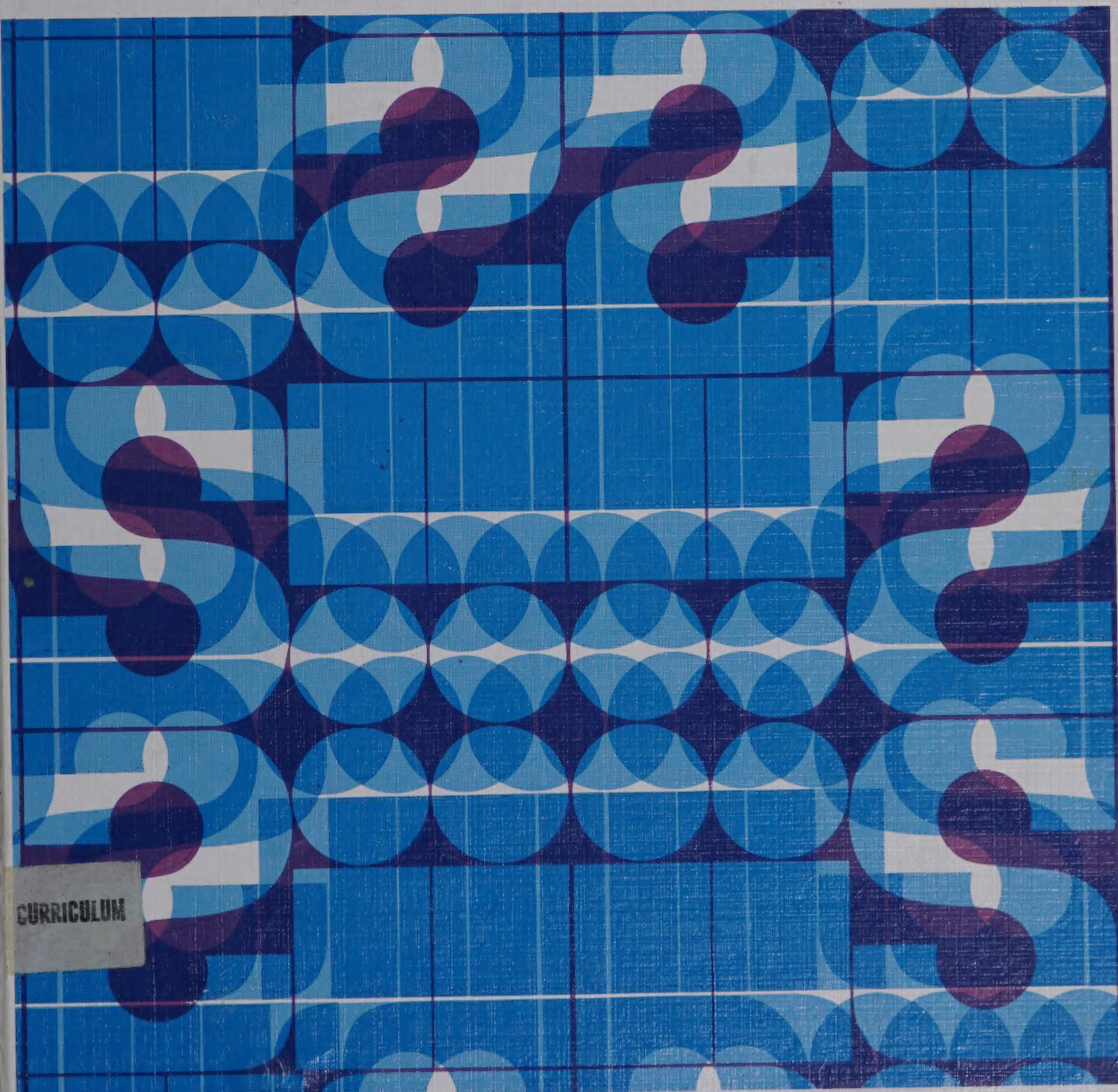
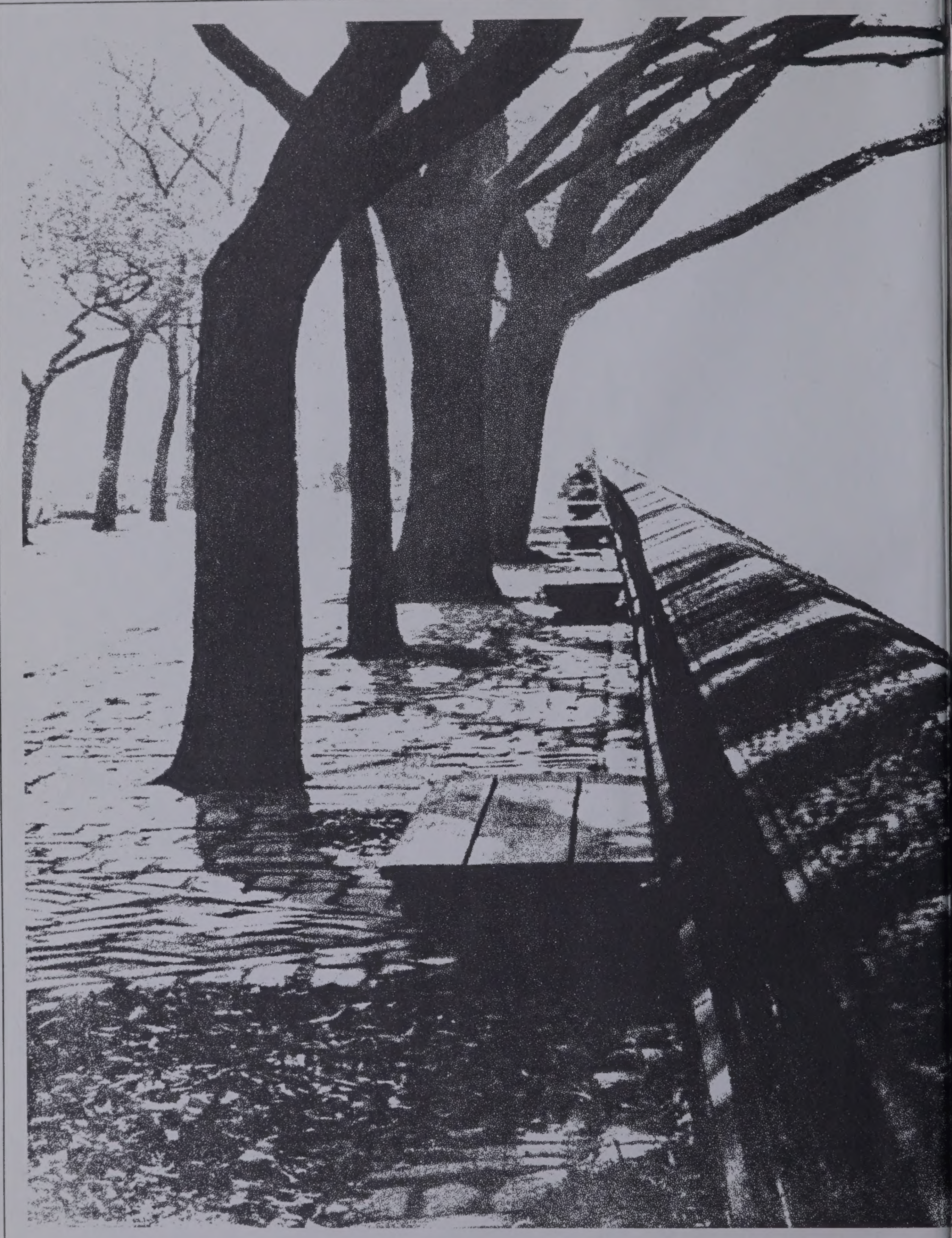
Wong and Dolmatz

BIOLOGY

IDEAS AND INVESTIGATIONS IN SCIENCE



IDEAS AND INVESTIGATIONS IN SCIENCE **BIOLOGY**



IDEAS AND INVESTIGATIONS IN SCIENCE

BIOLOGY

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entice-Hall, Inc., Englewood Cliffs, New Jersey

IDEAS AND INVESTIGATIONS IN SCIENCE

BIOLOGY
Idea 1: Inquiry
Idea 2: Evolution
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Idea 5: Ecology
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Laboratory Data Book
Teachers Manual
Laboratory Equipment

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Laboratory Data File

IDEAS AND INVESTIGATIONS IN SCIENCE-BIOLOGY

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Preface

Welcome to IIS! Here is a course where you spend your time doing instead of sitting. No one is going to tell you all about science. Instead, you will have the fun of finding out for yourself.

The key to IIS is what you do in the laboratory. When you want to know what things are made of, find out in the laboratory. When it's something about how living things behave, you can get the word on that in the laboratory. In fact, in this class, you will find that the class *is* the laboratory.

Maybe your question is "What is atomic energy all about?" or "How come some people are taller than others?" Do you want to know why an Eskimo and a Hawaiian have the same body temperature, or how a TV picture is made out of tiny dots of light? Tune in on this course — it's made for you!

You are beginning to see the picture. IIS is not learning about science — it's really exploring your world. You will be doing what a scientist does, asking questions, guessing answers, and testing your ideas in the laboratory.

One thing about the lab work. In addition to discovering new facts, like what happens when two chemicals are mixed together, you'll be finding out what the facts *mean*. You'll discover a concept, a small idea about how something in nature works. Then you can look back over a set of these concepts and see some pattern to them. This gives you a big idea about how things work. This is just what scientists do, too: they build big ideas out of small ones.

So what is it with all this science jazz? Everyone is talking science, but what is it to you? Look around you. We have a surplus of problems. Too many people to feed. Too much pollution. Coast to coast traffic jams. You name it and someone is sweating it, but who is supposed to come up with the answers?

Most people are looking to science for answers, or at least a clue on how to solve the problems. If you want a piece of the action, then you have to know what science is all about. Here is where IIS comes in.

You will find out about the population explosion and pollution. You will also get into jobs and automation, drugs, smoking, and natural resources. You will find out that science is right here and now, not what someone else was doing 2 zillion years ago.

When the coach wants you to learn to play basketball, he doesn't lecture you about the size of the ball or the height of the hoop. He gives you a ball and you start shooting baskets. If you are learning to make a dress, you don't start by hearing about the theory of weaving fabric, but get started with scissors, pins, and patterns. This is the way it is with science in IIS. You get involved.

By now this is all starting to sound too good to be true. There must be a catch. What about grading? And those science tests to clobber you?

Like the ads say, "It's performance that counts." In IIS what you do in the laboratory is the most important part of your grade. You won't be memorizing long lists of chemicals or parts of the body. Those aren't science anyway. What counts most is how you do the investigation.

Still wondering about this science course? You have been promised things in school before, so you won't fall for this line too fast. That's all right. Science doesn't take anything for granted. It has to have proof. Come on in and try IIS. We can prove that this course is for you. All you have to do is try it!

Harry K. Wong
Malvin S. Dolmatz

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Investigation 1

Whatever Turns You On

Some people are turned on by hard rock. Other people are turned on by the latest fashions. Fat Albert is turned on when he sees a buck-buck game. What turns you on?

Fat Albert

If you were a scientist, a problem would turn you on. But you have to recognize a problem first. How good are you at recognizing a problem?

A. JASMINE OR PEKOE?

Some people put lemon in their tea. They do this because they like the taste. But they never notice something else that always happens.

You will be given a cup of hot tea. Use a dropper to add one drop of lemon juice. Stir.

No, don't drink it. Look at it.

Record all your answers in your data sheet.

1. Describe what happens.

2. What problem do you see?

Now add a small pinch of baking soda to the tea.

3. Describe what happens.

4. What problem do you see?

Do you think the same thing would happen if the tea were cold?

B. HOW'S YOUR BREATH?

Who do you think can blow a card farther, a girl or a boy? Take a class vote before you begin.

5. How many voted for the boys?

6. How many voted for the girls?

After voting, your teacher will give you a card. Follow the directions you will be given. If you think you need a ruler to measure distance, be sure to ask for it.

Now let's see who wins, the boys or the girls. Huff and puff all you want.

7. Who won? Tell what happened.

8. Do you see the problem? What is it?

C. HOW ARE YOUR MUSCLES?

Here's a chance for the boys to get even with the girls, or vice versa.

You have probably lifted a chair many times. Look at the picture. Who do you think can lift the chair higher, a girl or a boy? Take a class vote.

9. How many voted for the boys?

10. How many voted for the girls?

11. How many voted for neither?

In trying to lift the chair, each class member must follow certain ground rules:

a. Both heels and seat must be against the wall at all times.

b. Do not bend your knees.

c. Bend from the waist and grab any part of the seat of the chair.

Go ahead and lift the chair.

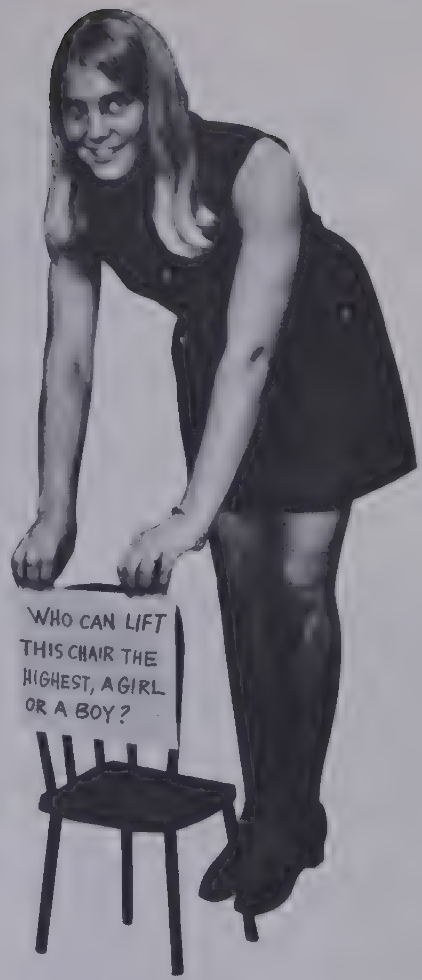
12. Who won? Who could lift the chair more easily?

13. Anything puzzling you? What problem do you see?

D. "ONE GIANT LEAP FOR MANKIND"

On July 23, 1969, Buzz Aldrin said of his historic Apollo 11 flight: "This stands as a symbol of the insatiable curiosity of all mankind to explore the unknown."

To stand on the surface of the moon! Have you ever stared into the vastness of space and wondered what that experience would be like?



Buzz Aldrin

NASA

It has always been man's dream to go to the moon. Although men have landed on the moon, the dream of further explorations remains.

This is what science is all about. Science is a way of exploring, of discovering, of finding out, of satisfying one's curiosity. But before any of this can happen, a scientist must do one thing.

14. What must a scientist recognize first?

You have come to the end of the first investigation. All are written in this manner. You will learn from what you do in class. You will talk about things in class. What you learn will be yours to keep.

From what you do in class, you will discover many specific ideas. We will call each specific idea a *concept.*

CONCEPT SUMMARY. (What general concept have you learned in this investigation?)

BIOLOGY Idea 1 Inquiry

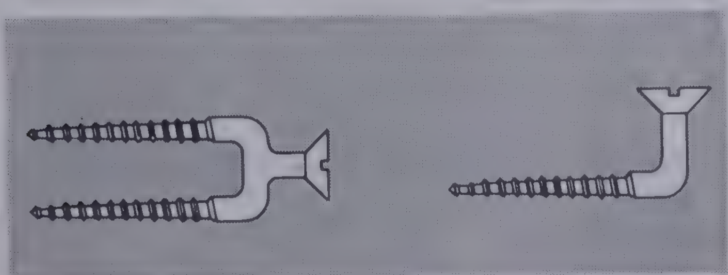
Investigation 2

Man, We Need Changes

Why do people, born with eyes, remain blind to the problems of society?

Why do people, born with brains, allow their minds to expand beyond their limits?

Fritz Henle from Monkmeyer



Eugene Anthony from Black Star

Look at the screws pictured above. Some people may not see anything unusual. In other words, if you don't see the problem, you're not going to think about it.

As you learned in the first investigation, one of the most important traits of a scientist is that he tries to recognize problems. But it isn't that easy to recognize problems. Some people see nothing wrong in the three pictures above. Do you?

A. ANOTHER SNACK?

We had tea in the last investigation. It's crackers today. You will be given one cracker. Put it in your mouth and bite into it.

1. Describe its taste.

Chew the cracker but do not swallow any of it!

Continue to chew and chew and chew. *Don't swallow.* You may have to chew for two or three minutes before you notice anything happening.

Some of you may laugh. That's all right. It's fun. Who says science can't be fun? Some of you may think this is silly. That's all right too. Many people thought Columbus was crazy for believing that the world was round. On the other hand, some of you may notice something.

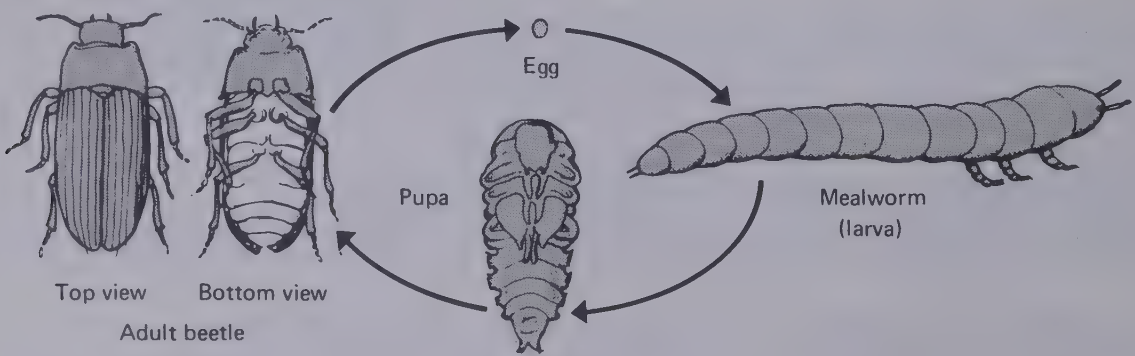
2. Describe any change that you notice.

Man is born with a sense of taste. With this sense, he can observe many things. Did you observe anything?

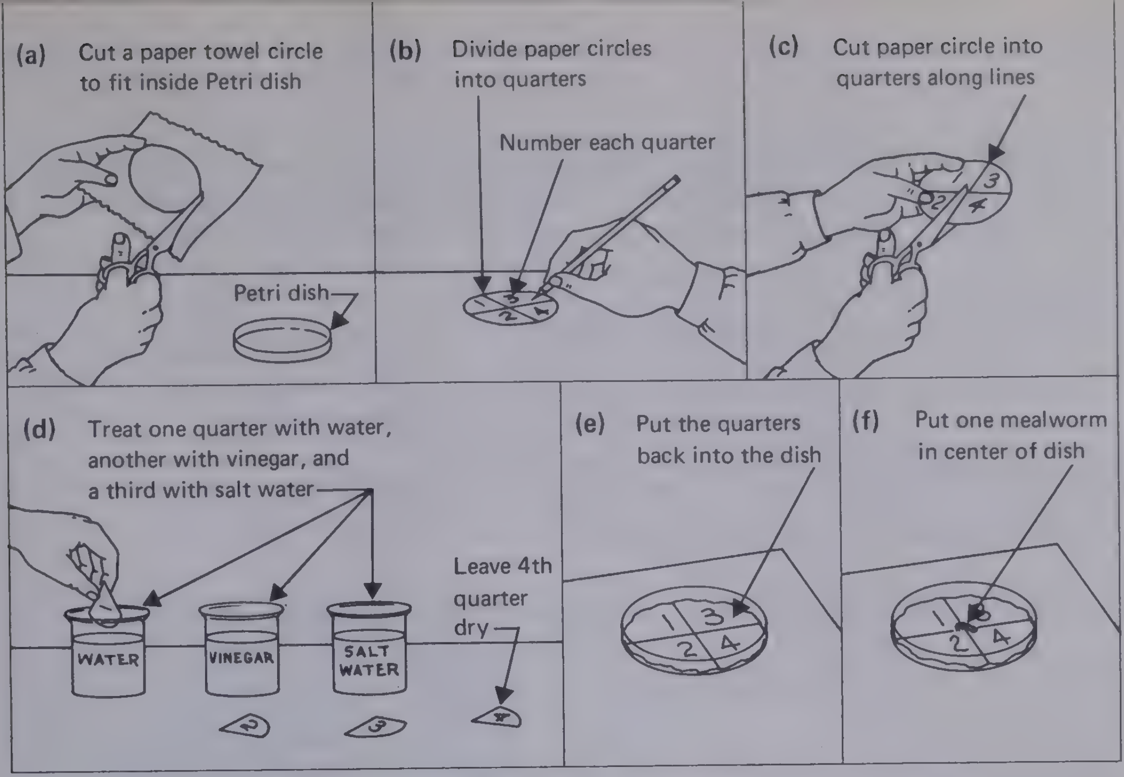
B. THIS WORM'S TOO MUCH

The most common animal used in a biology classroom is not a frog, a fish, or a mouse. It is a harmless animal called a mealworm. If any lizards are kept in the classroom, they are probably fed mealworms. Mealworms are the larvae of grain beetles. The grain beetle, like many other insects, has four stages in its life cycle: egg, larva, pupa, and adult.

The Life Cycle of the Mealworm



You will be given a Petri dish. Cut a piece of paper towel to fit inside the dish. Use a pencil to divide the circle of towel into four parts. Number each part or quarter, and then cut the towel along your pencil lines.



Treat each quarter as indicated below, and then put it back into the dish:

quarter 1—wet with water

quarter 2—wet with vinegar

quarter 3—wet with salt water

quarter 4—leave dry.

Put one mealworm in the center of the dish. Observe it for 5-10 minutes.

Describe what you see in space *a* in your data sheet. Use words, drawings, and diagrams.

Man is born with a sense of sight. With this sense, he can observe many things. Did you observe many things?

C. LET'S PLAY NINE SQUARE

Here is a game that will really test your powers of observation.

If the class is small, sit in a circle, and put nine magazines on the floor. Arrange the magazines in three rows of three each to form a square. (You can also play the game by drawing nine squares on the blackboard or on an overhead projector.) The pattern of the squares is pictured above.

Your teacher will ask one student to leave the room. While this student is gone, the class will choose one of the nine magazines or squares. The returning student will be able to point out the chosen magazine or square by noticing something the teacher does.

Can you spot or detect the action of the teacher?

3. If you think you know how it's done, explain.

Man is born with the power to observe, to perceive. How's yours?

D. YOU CAN SEE BUT STILL BE BLIND

All of the activities in this investigation have had one thing in common.

4. They were all designed to get you to use some of your senses and to test your power of __?__

After all, if you can't see the problem, there won't be anything for you to solve, to be curious about, to discover, or to explore. Until you see the problem, there won't be any change.

5. Therefore, what must you do to see or recognize a problem?

CONCEPT SUMMARY. (What general concept have you learned in this investigation?)

Investigation 3

Don't Be Afraid To Guess

Would you believe that guessing is a proper scientific trait, and that scientists often guess at possible answers? To see what this means, let's review what you have already learned.

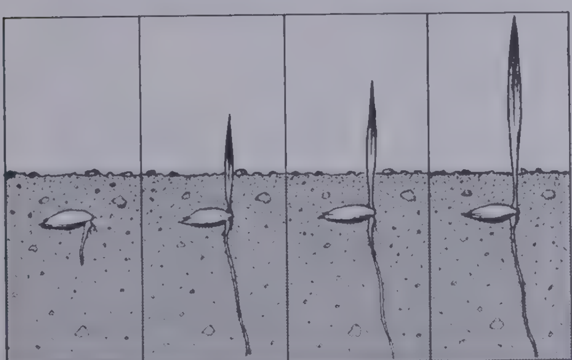
"Would You Believe 99?"

This is what you have learned so far:

a. A scientist must be able to recognize problems.

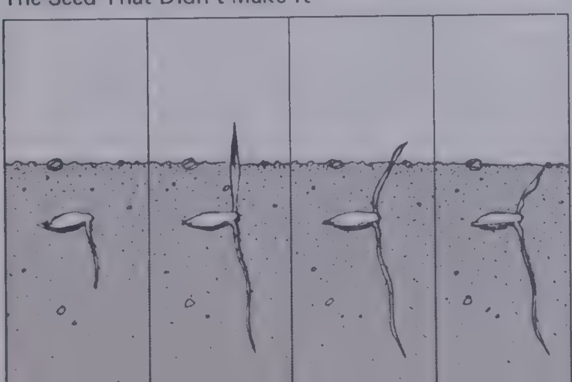
b. Accurate observations are necessary in order to recognize problems.

What does the scientist do after he has recognized a problem?



The Seed That Made It

The Seed That Didn't Make It



A. LET'S WRAP IT UP!

Study the pictures carefully.

1. Do you recognize the problem? What is it?

You will be given two pieces of plastic, both about 8 inches x 8 inches.

2. Describe both pieces of plastic.

One piece of plastic is similar to the type used to cover clothes that have been dry-cleaned. It usually bears the printed warning "Do not use in cribs, beds, carriages, or playpens. This is not a toy."

Greenhouse Covered With Plastic

3. What is the reason for this warning?

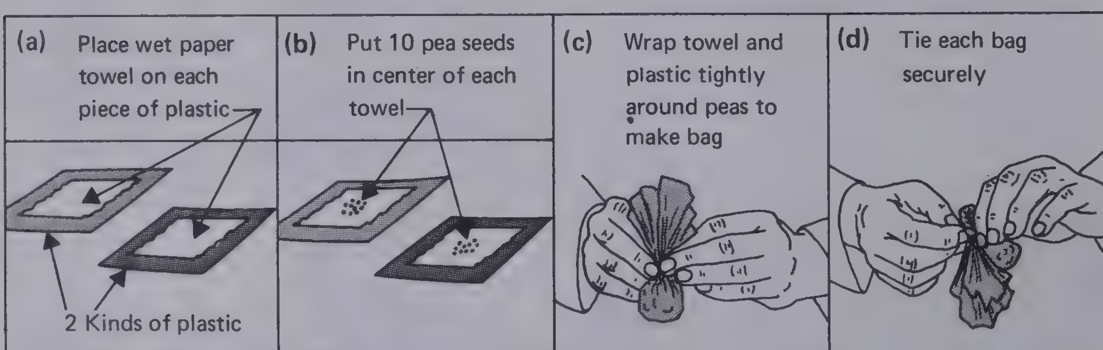
The other piece of plastic is similar to the plastic used to cover certain greenhouses.

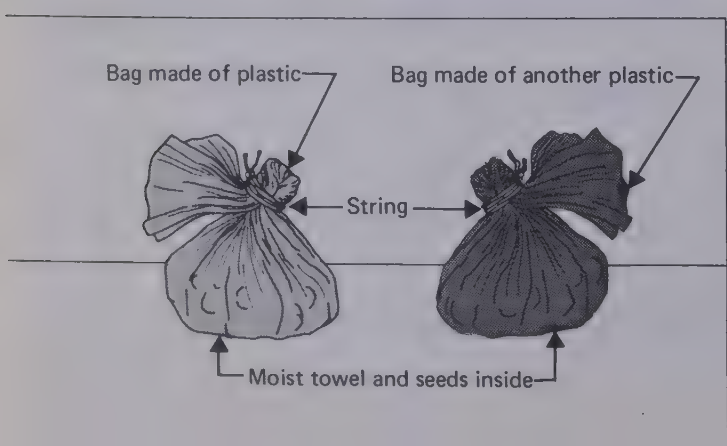
Think about this problem. Would you cover a greenhouse with the kind of plastic used to cover clothes?

What do you think would happen to two groups of pea seeds if they were each wrapped in the two kinds of plastic? You are not being asked to make any wild guesses. Study the pictures on this page. You should now be able to make an intelligent guess.

4. What do you predict will happen to the pea seeds after two or three days?

5. Explain your answer to question 4.





Place a piece of wet paper towel on top of each piece of plastic.

Count out 20 pea seeds. Put 10 pea seeds in the center of each piece of paper towel. Tightly wrap the towel and the plastic around the peas to make a bag. Tie the bags securely. Keep both bags at room temperature. After 2-3 days open both bags.

6. Describe what happened.

7. How do the results compare with your prediction?

Now that you are finished with the peas, let's see why you were asked to make a prediction.

Here are some results from other experiments:

a. Erica got 92.6.

b. I got four in one and seven in the other.

c. If you turn left, you will get there.

8. Explain what these results tell you.

Let's say that your answer to question 6 was, "Nine seeds sprouted in the thick plastic bag and two in the thin plastic bag."

9. If you repeated that sentence to a friend not in your class, how might he react?

10. Why would your friend be confused?

11. What would your friend have to know in order to understand the results?

12. Why are predictions useful?

B. THE MYSTERY BOXES

When the astronauts returned with the first boxes of moon rocks, scientists all over the world were eager to test their predictions. Some of the predictions made about the surface of the moon were proven to be true. Other predictions were proven to be wrong. How can scientists make predictions, sometimes correctly, about something so far away?

Teachers and textbooks tell you that atoms exist yet they cannot be seen. Scientists have made thousands of predictions about the atom and then tested these predictions. Results show many of these predictions to be correct. How can you make a prediction about something you cannot see?

You will be given a sealed box. *Without opening the box,* guess what kinds of material it contains.

13. Make a list of your guesses.

You now have a list of guesses. That's all they are, a set of guesses. Some people believe and react to guesses without attempting to test their accuracy. Do you ever see evidence of people reacting to guesses only?

Scientists, however, use guesses or predictions as a starting point.

14. What do you think a scientist would do with your list of guesses in question 13?

Your teacher will give each team of students an empty shoebox. Each team is to develop its own mystery box using objects supplied by your teacher. The object of this game will be to identify the number, kind, and name of the objects in each mystery box and to score the highest number of points. See Table 1 in your data sheet. The rules of the game are as follows:

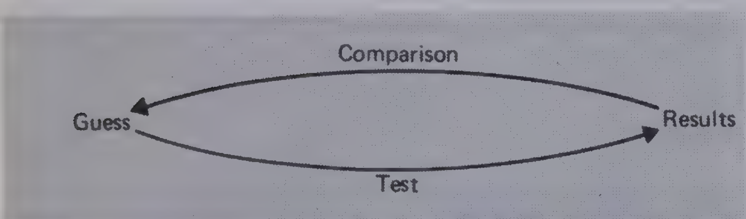
a. You can put no more than three objects in the box.

b. Label the box with a letter designated by the teacher.

c. The boxes are not to be opened. The rubber bands or tape are not to be removed.

d. Your teacher may set a time limit on how long you can examine each box.

Think about what you did with each box. You probably held each box close to your ear and listened for sounds. When you heard a sound, you tried to identify it by comparing it with sounds familiar to you. Then you made a key move. You made a mental guess. Then you tilted the box and listened for the same sound again to test your guess. You made many guesses, tested each guess, and compared the results of the test to your guess.



C. EACH GUESS IS A GUIDE

There is an old saying

"If you don't know where you are going, how will you know when you've arrived?"

15. Explain this saying in light of what you have just learned.

Do you now know why scientists make guesses?

CONCEPT SUMMARY. (What general concept have you learned in this investigation?)

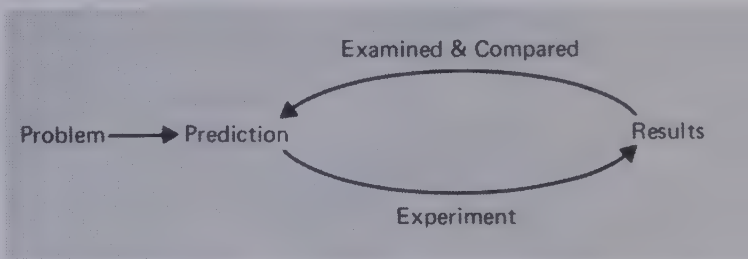
Investigation 4

Petaluma Is a Swinging Town

In the last investigation we learned about scientific guesses or predictions. Predictions are possible solutions to problems.

A prediction is no more than an educated guess. But this is not enough for a scientist. A scientist will always ask, "Where's the evidence?"

Therefore, a scientist tests his predictions. The test of the prediction is called an *experiment.* An experiment produces results which, when examined and compared to the prediction, tell the scientist if his prediction was correct.



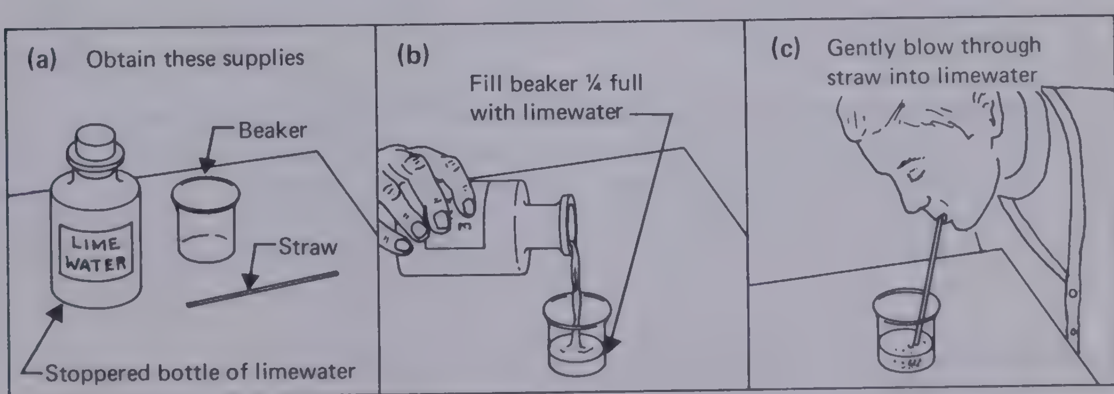
A. WHAT'S A PROPER EXPERIMENT?

Do you believe the following statement? "When we exhale, we breathe out carbon dioxide." How do you know if it's true or not? Well, you can always do an experiment and find out.

You will be given a container and a straw. You will also be given some limewater (the chemical lime and water mixed together). Pour a small amount of limewater into the container. Gently breathe the air from your lungs out through the straw into the limewater.

1. What happens to the limewater?

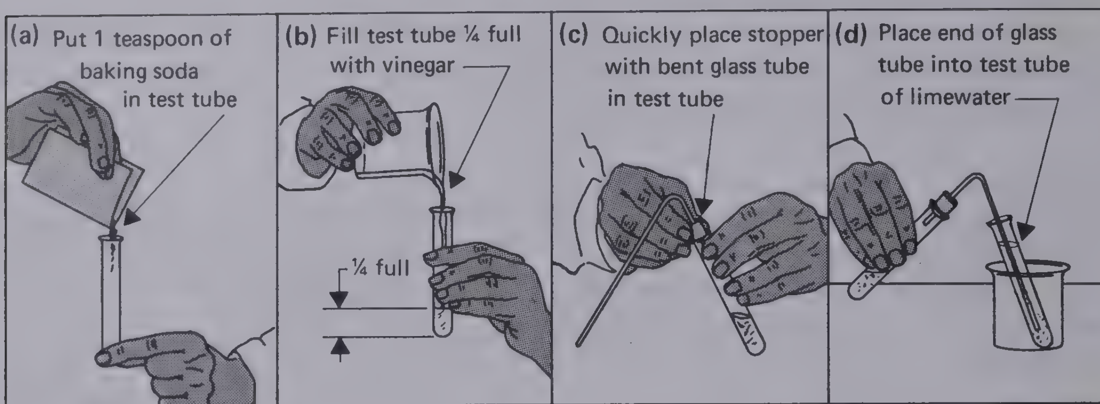
2. What is the one thing that probably caused the change?



3. Do you have any proof that carbon dioxide caused the change? Explain your answer.

4. In order to be certain it was the carbon dioxide that caused the limewater to change, what should you do?

There are two easy ways to obtain carbon dioxide. One is to put a piece of Dry Ice in water. The bubbles that come off are carbon dioxide. Another way is to mix some baking soda and vinegar as pictured below. Set up the apparatus.



5. Bubble the carbon dioxide through the limewater. What happens to the limewater?

Let's review what you've done. You breathed into limewater and it turned cloudy. You then obtained some carbon dioxide and bubbled it through limewater. You got the same result.

With these results, you might conclude that:

6. When we exhale, we breathe out __?__

7. We tested and proved this because our breath turned limewater __?__

B. BUBBLE, BUBBLE, BUBBLE

Was it the carbon dioxide in your breath that caused the limewater to turn cloudy?

Scientists talk about *controlling variables.* A variable is any factor that could affect the results of an experiment. You had better reconsider your answers to questions 6 and 7: more than one variable was present. What other factor could have turned the limewater cloudy?

Think about the two experiments you did in part A.

8. What else could have turned the limewater cloudy?

To solve this problem, we will have to set up a *controlled experiment.* (Let's find out why we call the following activity a controlled experiment.)

You will be given two containers, some rubber tubing, and a Y-shaped glass tube. These items are pictured in drawing *a* on your data sheet.

You are going to inhale and exhale through the Y-shaped glass tube. Attach one piece of tubing from the Y-shaped tube so that your breath bubbles into one of the containers of limewater. Attach the other piece of tubing from the Y-shaped tube so that room air bubbles into the other container of limewater. How you attach the tubing is a problem you will have to solve.

As you proceed with this task, you will be doing what you learned in the last three investigations. You will recognize the problems, make guesses, test these guesses, and try again if the results tell you that you were incorrect. Complete drawing *a* to show how you attached the tubing. Draw arrows to indicate the direction your breath and the air will flow.

9. Make a prediction. What do you predict will happen when air is bubbled through one container of limewater and your breath is bubbled through another?

Have your teacher check your experimental setup. Then obtain some fresh limewater, and do the experiment.

10. Explain whether it was only the action of the bubbles that caused the limewater to turn cloudy.

11. Which container of limewater turned cloudy?

12. If you were to continue to bubble room air into the limewater, what do you predict would eventually happen?

(Ask your teacher for permission to test this prediction.)

13. What do you conclude about the amount of carbon dioxide in your breath and in the air?

Refer to drawing *a* in your data sheet. Notice that both containers are identical. Both have the same amount of limewater. The glass and rubber tubing are attached to the containers in the same way. And both containers have the same amount of bubbles moving through them.

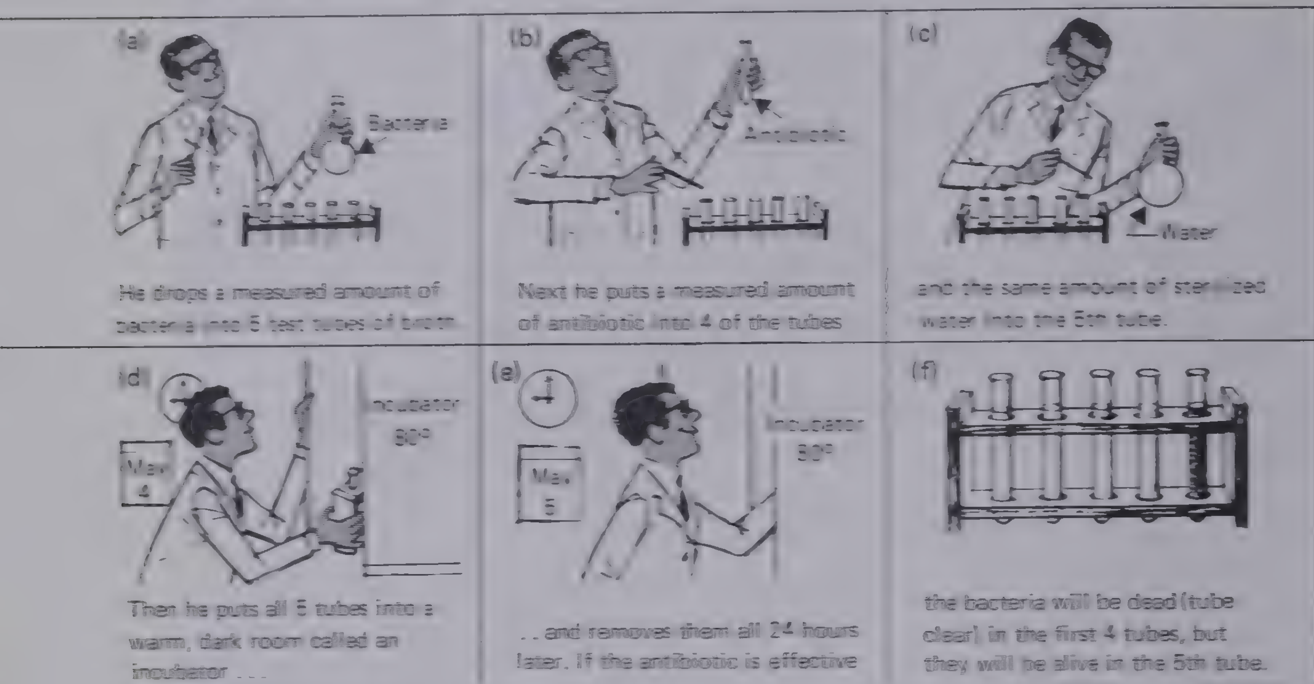
14. What factors can you rule out as a cause of the limewater turning cloudy?

15. Therefore, what is the only factor that differs from one container to the other?

The container that holds the test of your prediction (see question 9) contains the *experimental* factor. The other container which serves as the check lacks the one factor that is different and is called the *control.*

Go back to drawing a and label the experimental container and the control container.

The concept of a control can be shown by seeing how a bacteriologist tests the effectiveness of a new antibiotic.



16. What was the control in this experiment?

17. Why is it the control?

C. WHERE'S PETALUMA?

Linda Moyer says Petaluma is a swinging town.

18. What is lacking in Linda's statement?

You have been learning about controlled experiments. Review the concept studied in the last investigation. Then answer the following questions.

19. What is the purpose of an experiment?

20. What kind of an experiment should be used?

CONCEPT SUMMARY.

Investigation 5

Weird Harold Weighs 45,500

Advertisements and TV commercials constantly use the words *faster, brighter, larger, more expensive, better looking.* These words mean very little. For instance, "The boy is faster" doesn't mean a thing. How fast is the boy? The boy is faster than what?

It is more accurate to say: Stewart is faster than Scott. Stewart runs the 100-yard dash in 10.00 seconds.

Note that there is a control or a check in these two statements. In the first sentence, the control is another boy. In the second sentence, the control is time. The last sentence is possibly better because it states exactly how fast Stewart runs.

Whenever possible, scientists try to show the results of their experiments numerically.

A. CHOOSE A LABEL

You will be given a stick and a length of tape marked with lines and numbers. Apply the tape to the stick lengthwise so that the lines are along one edge, as in a ruler.

1. What is the total number of spaces between each pair of numbers?
2. How much does each space equal?

At this point your measuring stick is useless. Yes, you could make measurements, but such results as 0.5, 7.4, and 15.2 are meaningless. There are no units.

The class needs to decide on a name for the unit of length between each pair of numbers. This name is simply a label chosen to let everybody know what is being talked about.

3. What has the class decided to call the units of length between each pair of numbers?
4. By using the measuring stick and the unit the class has decided on, measure the objects assigned to you by the teacher.

B. DO YOU WEIGH MORE THAN WEIRD HAROLD?

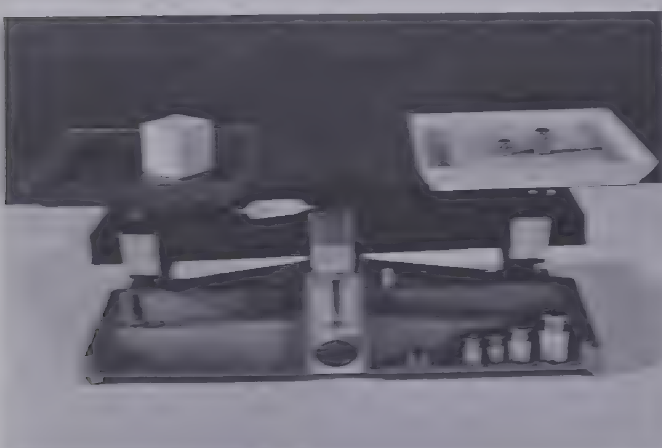
Step on the bath scale, and note your weight. When you see what you weigh, don't panic. The numbers have been changed.

Again, there are no units. Your weight is meaningless. The class will have to decide on a name for the units of weight between each pair of lines.

5. What has the class decided to call the unit of weight between each pair of lines?

Your teacher will have another weighing device. It is a balance. Notice that it is built like a seesaw. The object to be weighed is put on one side and is balanced by known weights on the other. You will be shown how to use it.

How Can Someone as Thin as Weird Harold Weigh 45,500?



A Balance

You will be given a number of items to weigh. Weigh these on the balance assigned to you. These same items will be weighed by other students on their balances. In addition, these items will be weighed on the bath scale.

6. Record your results, the results of two other groups of students, and the results on the bath scale.

7. How did your weighing of an object compare with the weighing of the same object on the other balances?

8. Can you get an accurate weighing of a paper clip (or other light object) on a bath scale? Why or why not?

9. If the results of the different weighings were not the same, how might you explain the differences?

10. Does the name of the unit affect the accuracy of the weighing? If not, what does?

C. YOUR OWN MEASURING CUP

In the last two parts you were given a measuring stick and a balance already marked with units. You learned that the name of the unit is simply a label chosen for ease of communication. The name of the unit does not affect the accuracy of the measurement. The accuracy of a measurement is determined by other factors, including the quality of the measuring device and the ability of a person to use and to read the measuring device.

Would you be able to measure something accurately if you had to make your own measuring device?

Graduated Cylinder

While on a camping trip, Loretta, a usually prepared Girl Scout, discovered that she had forgotten to bring a measuring cup. So she set out to make her own. She laid a coin on a piece of tape and drew lines at equal distances from one another. She then applied the piece of tape to a jar. Loretta held up her new measuring cup to admire it.

11. Will her jar be an accurate measuring device? Explain.

12. If you were given a jar and a piece of tape, how would you improve upon Loretta's measuring jar?

You will be shown a container shaped like a cylinder. Lines have been permanently etched into the cylinder. The container is used for measuring volume and is called a graduated cylinder.

13. How many spaces are there between each pair of numbers?

14. What does the distance between each pair of numbers equal?

The class should decide what to call each unit of volume.

15. What has the class decided to use as its unit of volume?

Since the graduated cylinder has a known volume, you can make a volume-measuring device out of a jar and a piece of tape. Do this.

You have used a measuring stick to measure distance. You have also used a scale or balance to weigh objects. Now use your measuring jar to determine volume.

You will be given the following items: a. your measuring jar; b. a straw or rubber tubing; c. a large pan; d. all the water you need (and a mop if you are not careful).

With these items how would you construct a device to measure how much air you could exhale in one breath? Diagram your answer in space *a*.

16. Gently exhale one normal breath into your measuring jar. Repeat this two more times. Record your results for each trial.

17. Add all three numbers together and divide by three. What is your average?

18. Compare your average volume of exhaled air with some of your classmates. Complete the missing information on your data sheet.

19. What are some factors that could have affected the accuracy of the measurements listed in question 18?

As you can see, numbers help to improve communication whenever measurements have to be taken. But numbers, by themselves, cannot guarantee accuracy. They only help to improve the accuracy. Many factors must be controlled to get accurate measurements.

20. What is wrong with the statement, "Weird Harold is thin"?

21. Explain what is wrong with the statement, "Weird Harold weighs 45,500."

22. The accuracy of measurements can be improved when they are written in what form?

23. For measurements to be meaningful to others, what should follow all measurements?

CONCEPT SUMMARY.

Investigation 6

Let's Get Organized

Does knowing a lot of facts make you a smart person? If you memorized the batting average of every player in last year's World Series, would that make you smarter than someone who did not?

Have you ever seen an almanac? Almanacs are packed with facts. If you could remember pages of information from an almanac, would that make you a smarter person?

TABLE NO. 1

WOMEN'S FREESTYLE

Distance	Time	Holder	Country	Where made	Date
100 meters	**0:58.9**	Dawn Fraser	Australia	Sydney, Aust.	Feb. 29, 1964
110 yards	**0:59.5**	Dawn Fraser	Australia	Melbourne, Aust.	Nov. 24, 1962
200 meters	**2:06.7**	Debbie Meyer	U.S.A.	Los Angeles, Calif.	Aug. 24, 1968
220 yards	**2:11.6**	Dawn Fraser	Australia	Sydney, Aust.	Feb. 27, 1960
400 meters	**4:24.5**	Debbie Meyer	U.S.A.	Los Angeles, Calif.	Aug. 25, 1968
440 yards	**4:38.8**	Kathy Wainwright	Australia	Kingston, Jamaica	Aug. 12, 1966
800 meters	**9:10.4**	Debbie Meyer	U.S.A.	Los Angeles, Calif.	Aug. 28, 1968
880 yards	**9:44.1**	Debbie Meyer	U.S.A.	London, England	Sept. 30, 1967
1,500 meters	**17:31.2**	Debbie Meyer	U.S.A.	Los Angeles, Calif.	July 21, 1968
1,650 yards	**18:47.8**	Angela Coughlan	Canada	Hamilton, Ont.	July 27, 1968

Here is a table from an almanac. Note that the table:

a. is well organized

b. contains only specific information

c. organizes information so that you can find facts rapidly

The table begins with a title.

1. What is the table about?

The table is divided into a number of columns. Each column has a brief explanation at the top. Let's see if you can read the table.

2. Who holds the current world's record in the women's freestyle for the 200 meters? 3. Where was the world's record in the women's freestyle for the 800 meters made? 4. What does the number 2:06.7 represent? 5. What record was broken most recently?

Debbie Meyer

A. HERE'S TO A LONG LIFE

A table is used to organize information. Scientists constantly use tables because they help organize the results of experiments. The results of experiments are called *data*. Scientists often draw the framework of tables first. Then as the experiment progresses, data can be recorded quickly and accurately.

There is nothing hard about drawing a data table. Look at Table 2. The following steps are useful in preparing a table: a. Use a title that describes the table completely; b. draw a box around the entire table; c. divide the table into appropriate columns; d. place the largest heading at the top of the table; smaller headings beneath the larger headings; e. put the units in the heading.

TABLE NO. **2** AVERAGE FUTURE LIFETIME IN UNITED STATES

Source: U.S. Dept. of Health, Education and Welfare National Center for Health Statistics, 1966 Data

		Average remaining lifetime[2]				
			White		Nonwhite	
Age interval	Number living[1]	Total	Male	Female	Male	Female
0-1	100,000	70.1	67.6	74.7	60.7	67.4
1-5	97,639	70.8	68.2	75.1	62.4	68.8
5-10	97,276	67.1	64.4	71.3	58.8	65.2
10-15	97,063	62.2	59.6	66.4	54.0	60.4
15-20	96,863	57.3	54.7	61.5	49.2	55.5
20-25	96,368	52.6	50.1	50.7	44.6	50.7
25-30	95,727	48.0	45.5	51.8	40.3	46.0
30-35	95,072	43.3	40.8	47.0	36.0	41.4
35-40	94,258	38.6	36.2	42.2	31.9	37.0
40-45	93,118	34.1	31.6	37.5	28.0	32.8
45-50	91,390	29.7	27.2	32.9	24.2	28.8
50-55	88,753	25.5	23.1	28.5	20.8	25.0
55-60	84,779	21.5	19.3	24.2	17.6	21.3
60-65	79,029	17.9	15.9	20.2	14.9	18.1
65-70	71,298	14.6	12.9	16.3	12.4	15.2
70-75	60,781	11.6	10.3	12.8	11.0	13.4
75-80	48,078	9.0	8.0	9.6	9.8	11.2
80-85	34,040	6.7	6.1	6.9	8.4	9.2
85 and over	19,855	4.7	4.4	4.7	6.7	7.0

[1] Of 100,000 born alive, number living at beginning of age interval.
[2] Average number of years of life remaining at beginning of age interval.

Courtesy 1969 World Almanac

There are 133 pieces of information in the table. Can you imagine writing 133 or more sentences to describe the results? It's much easier to use a table. Although this table is more complicated than the last one, you should have no trouble answering these questions:

6. What is the table about?

7. What kind of a person will have the longest lifetime?

8. What does the column "total" represent?

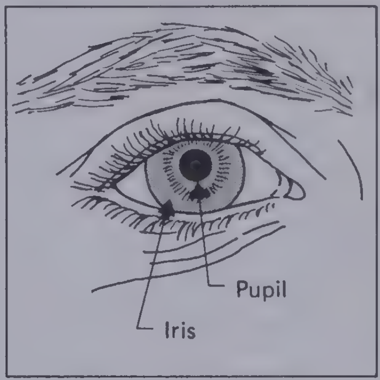
9. What does the number 32.8 in the last column represent?

Use the two tables you have been studying as your model. You will now design your own data table based on your own experiment.

B. PLEASE WINK AT ME

Do you know why you squint when you move from a dark to a bright room? After your eyes become adjusted or "used" to a dark room, do you notice that you can see a great deal in the darkened room? Why does this happen?

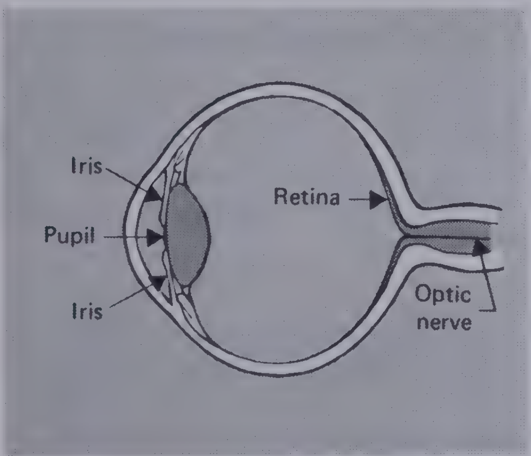
Take a look at your eye in a mirror, or look into a friend's eye. The black spot in the center is the pupil. It is black because it is a transparent opening into the dark interior of the eyeball.



The Human Eye

What you see comes to your eye in the form of light rays. The light passes through the pupil of the eye and falls on the back part of the eyeball. The back part of the eyeball is like a movie screen. Nerve fibers carry the picture to your brain for interpretation.

What if the amount of light changes? What happens to the pupil of the eye?



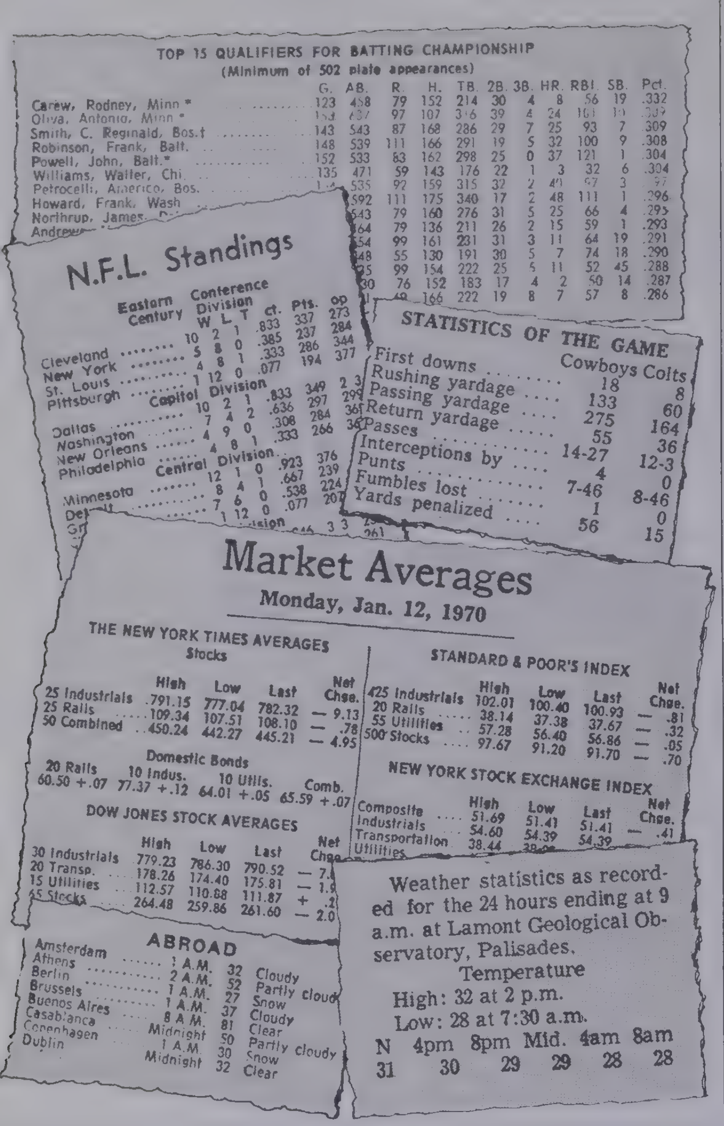
10. What do you predict happens to the pupil of the eye as the amount of light changes?

11. Now that you have made a prediction, what should you do next?

You will be given a flashlight and the ruler you made in the last investigation. A group of four students should do this experiment. One student should be the subject; one should hold the flashlight; one should measure the size of the pupil; and one should record the results.

The results that you collect will be called the *experimental data.* It is important that you organize yourself before proceeding. Before you start the experiment, answer these questions:

a. What are you going to look for? (Remember we once said, "How do you know you've arrived, if you don't know where you are going?")



Sample Data Tables

b. How are you going to record your data?

c. Do you have a place to record all the data?

Do you know where you are going in this experiment? Have you thought about such things as:

a. the amount of light in the room?

b. where to place the subject?

c. at what angle to hold the flashlight?

d. at what distance to hold the flashlight?

e. how long to shine the light at the subject?

f. what will be your control?

g. how to get accurate measurements?

A good data table is the result of careful planning. All data tables should be kept as simple as possible. For instance, the table for this experiment can be as simple as two columns.

Reread your prediction in question 10. Design a table in space *a* which will hold the data to test your prediction. Don't forget the five rules for designing a table listed in part A.

Prepare the framework of the table before doing the experiment.

C. NICE AND NEAT

We use tables almost every day. There are weather tables, baseball box scores, and stock market reports. Check the newspapers and magazines to see how many you can find. Bring some of these to class.

12. What is the purpose for making and using data tables?

13. What is one way you can organize experimental data?

CONCEPT SUMMARY.

BIOLOGY Idea 1 Inquiry

Investigation 7

Can You See As Well As José?

José Feliciano has been blind from birth. Yet his blindness has not stopped him from having a full career. His singing has won him great admiration. But he is also admired for the many other things he can do.

Being blind is not a handicap that has defeated him. José is married, rides a bicycle, plays baseball, and wants to try straight acting. José doesn't believe in self-pity.

NBC-TV

José Feliciano

Even though you have good eyesight you can be blind to many of the things happening around you. You found this out in Investigation 2.

To help picture the data in a table, a scientist often uses a *graph* to show his results. A graph shows the connection between two or more things.

Graphs are important because:

a. They help organize data.

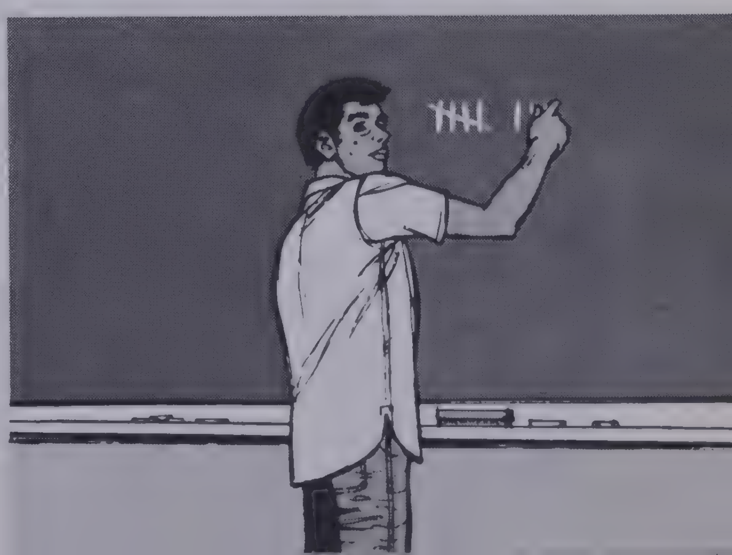
b. Their picture form makes it easier to interpret data.

c. Predictions can be made based on their data.

There are many kinds of graphs. We will be concerned with only three kinds: histograms, bar graphs, and line graphs.

A. HOW TALL IS YOUR HISTOGRAM?

You have all made tally marks. You frequently use the tally system to keep track of votes in a class. A histogram can be used to keep track of tally marks, too.



Measure the heights of all the students in the class and record this information in Graph 1 on your data sheet. What brief, but complete title should be used to describe your results? Put the title on the line above the histogram.

Remember what has been stressed. Know what you are doing before you start. Measuring the heights of the students will be the easiest task. What are you going to do with the measurements?

There are four rules you must follow in making a histogram. These rules will apply to a type of graph paper with lines drawn on it to form grids.

a. Draw a box with lines in it to form grids that are equally spaced.

b. Use a pattern of numbers that are consecutive. That is, do not skip in the order or pattern of the numbers.

c. Label each side of the grid to indicate what the numbers stand for.

d. Indicate the units for each side of the grid.

The histogram will be used to compare two sets of numbers.

a. The heights of the students. These numbers are listed across the bottom (horizontal) side of the grid.

b. The number of students for each height. These numbers are listed along the vertical side of the grid.

The possible heights of the students are listed across the bottom line. Find out who is the shortest and who is the tallest person in the class. List the span of heights from the shortest to the tallest person across the bottom side of the grid. List each height under a column; that is, between the vertical lines.

1. What do you predict will be the most common height found in the class?

The possible number of students (for each height) are listed along the vertical side of the grid. Although you do not have to do so, it is customary to begin with zero or one. List the span of numbers along the vertical side of the grid between the lines.

Now we are ready to start. As the height of each of the students is measured, make an "x" for a tally mark in the square above the proper height.

2. According to the data in your histogram, what is the most common height in the class?

If you were to look at all the students in your class, it would be very difficult to determine the most common height. If you make a histogram, the task is easier.

3. How does a graph help an experimenter?

Now you will be given a probability game. Play with it a couple of times and notice how it works. Look carefully and find the one ball that is of a different color.

4. In what column do you predict the colored ball will fall most often?

Work the game at least 25 times and make a histogram of where the different colored ball falls each time.

In Graph 2 on your data sheet, design your own histogram to record the results of your experiment. Be sure to include a title and follow the four rules listed on page 26.

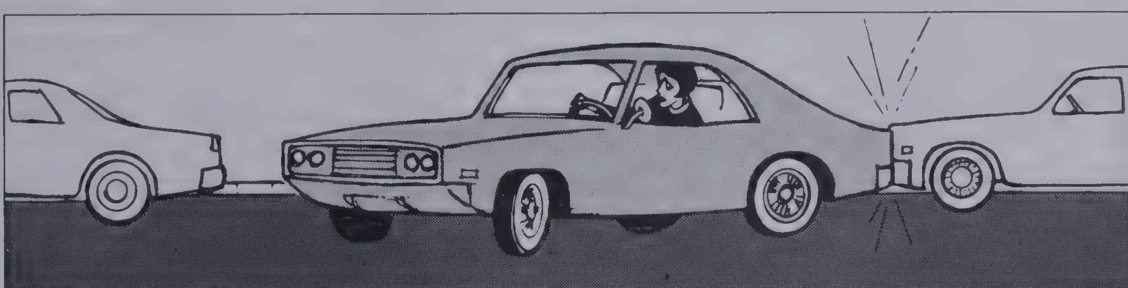
The purpose of an experiment is to provide data to support or reject a prediction. In other words, the prediction tells you where you are going. The experiment tells you whether you got there or not.

5. What do the data in your histogram tell you about the prediction you made in question 4?

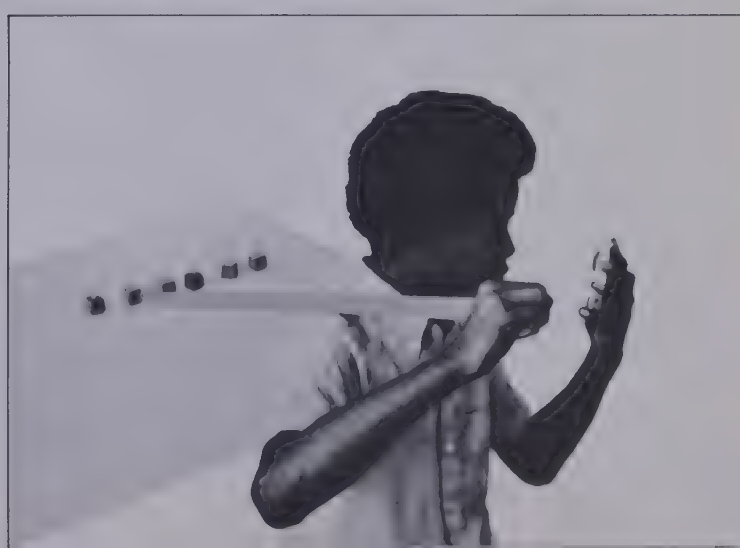
B. COLOR ME BROWN

A bar graph is similar to a histogram except that a solid bar is used instead of the "x" tally marks. To illustrate, copy the data from the histogram in Graph 1 to the grid in Graph 3. Now color in each square with an "x" in it. You have just made a bar graph.

Can you back into a parking space by looking into the rear view or side view mirror only, or do you have to look backwards out of the window? The next activity may help you to find the answer.



Two students should work together on this activity. Six blocks of wood will be placed one inch apart on a table. Each block has a hook in it. One student is to sit on a chair with his back to the blocks, holding a mirror in one hand and a stick in the other hand. (Note that the stick, which is about a yard long, has a hook in the end farthest away from the hand.) Holding the stick over his shoulder, he will try to pick up one block at a time.



The other student will serve as the timer. There will be a two-minute time limit on the task. Make a prediction first.

6. How many blocks do you predict can be picked up in two minutes?

Calculate the average class prediction for question 7. Do this by adding all the predictions made in class. Then divide the total by the number of predictions made. Use space *a* in your data sheet for your calculations.

7. What was the average class prediction?

Design the framework for a bar graph which will record how many blocks each student in class can pick up in two minutes. Do this in Graph 4.

Now try to pick up the blocks. After one student finishes, exchange places with the student who has been the timer. Record your own data as well as the class data in your bar graph. Calculate the average class result in space *b*.

8. What is the average class result?

9. How does the average class result compare with the average class prediction?

10. What do your data tell you about how well people think they can see?

Are you sure you don't want to back into a parking space using only a rear view or side view mirror?

C. HANG A LINE ON

There is only one slight change from a histogram or a bar graph to a line graph. The numbers at the sides of the grid are *not* placed between the lines. The numbers are placed at the ends of the lines. To illustrate, the numbers necessary for Graph 5 have been labeled for you already. These numbers were taken from Table 1.

TABLE NO. 1 EDUCATION AND DIFFERENTIAL EARNINGS OF MEN, BY COLOR*
(THOUSANDS OF DOLLARS)

Level of Education	White	Nonwhite
Elementary School:		
Less than 8 years	$157	$ 95
8 years	191	123
High School:		
1 to 3 years	221	132
4 years	253	151
College:		
1 to 3 years	301	162
4 years	395	185
5 years or more	466	246

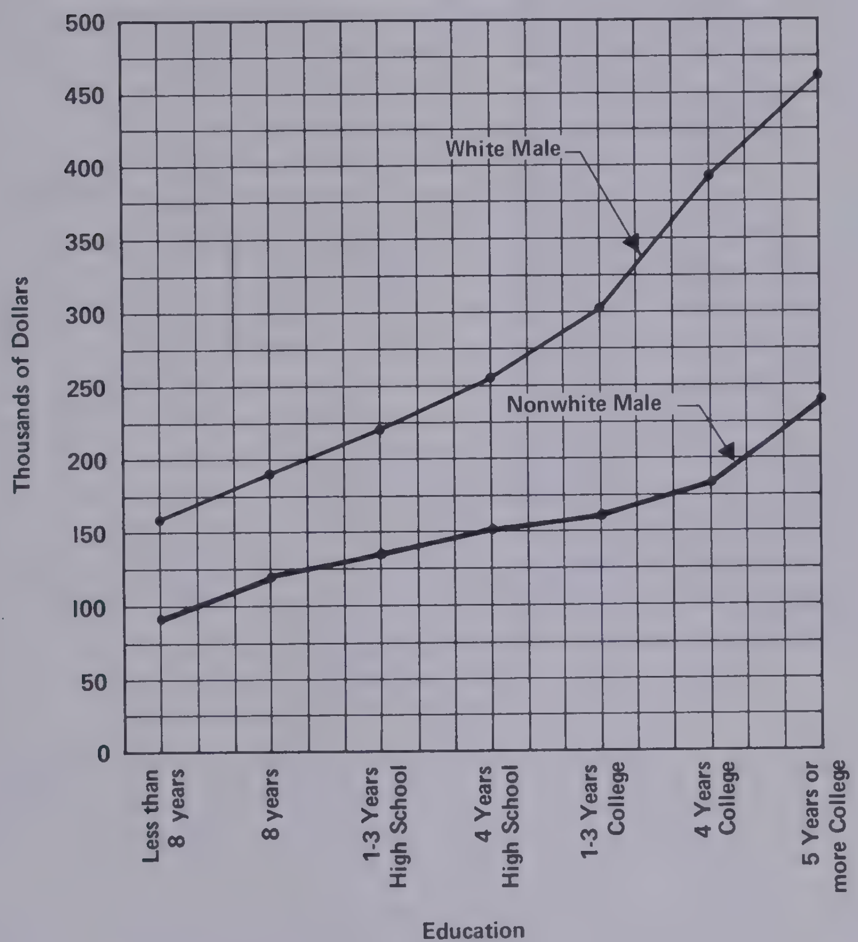
*For men aged 18 to 64. Derived from 1960 Census data. See U.S. Senate, 88th Congress, 1st Session, Hearings Before the Committee on Labor and Public Welfare on Bills Relating to Equal Employment Opportunities, July and August, 1963.

Reprinted from The American Negro Reference Book, edited by John P. Davis, Englewood Cliffs, N.J., Prentice-Hall, Inc., 1966.

Table 1 tells you that a white male with less than 8 years of education will have a lifetime earning of $157,000. Find the line in Graph 5 that stands for less than 8 years of education along the bottom line. Find the line that stands for $157,000 on the vertical line. Follow the line for less than 8 years of education upwards until you come to the vertical line that stands for $157,000. Notice that a point has already been made on the graph below where the two lines cross.

GRAPH NO. 5

EDUCATION AND LIFETIME EARNINGS OF MEN BY COLOR



The table also tells you that a white male with 8 years of education will have a lifetime income of $191,000. Find the point on the graph that stands for these two pieces of data. Do the same for the remaining data on a white male. You will have seven points when you finish. All seven points have been connected with a line and labeled "white male."

Repeat the same procedure for the data on a nonwhite male.

In part B you were asked to pick up some blocks of wood with hooks in them. You were to do this with a hooked stick while looking backwards into a mirror. As you discovered, few students (if any) succeeded in picking up all six within two minutes.

You were given only one chance to pick up the blocks in part B. If you were given another chance, do you think you could pick up more blocks?

11. If you were given five chances, each two minutes long, do you think you could pick up more blocks each time? What do you predict?

Design the framework for a line graph which will record how many blocks you can pick up in each of 5 two-minute periods. Do this in Graph 6 on your data sheet. Now go ahead and see how well you do this time.

12. How did your results compare with your prediction?

In summary, you have just learned how to draw three different kinds of graphs. But the important thing to know is that "one graph is worth a thousand words."

13. Therefore, why are graphs used?

CONCEPT SUMMARY.

Investigation 8

Do Your Own Thing

These are the concepts we have studied so far.

a. A scientist must be able to recognize problems.

b. Accurate observations are necessary in order to recognize problems.

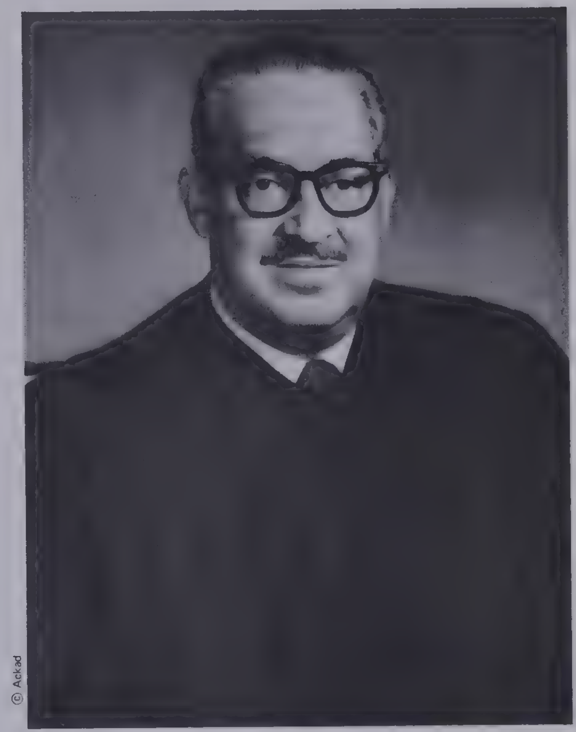
c. Predictions serve as possible solutions to problems.

d. Controlled experiments are run to test predictions.

e. Accuracy is improved when common units and numbers are used.

f. The results of experiments should be organized into data tables.

g. Graphs can be used to organize and interpret data.



Justice Thurgood Marshall

Have you ever seen the sign, "My mind is made up. Don't confuse me with facts!" It's bad enough when people make decisions without any facts to back them up. But it's even worse when the facts are there and people refuse to believe them.

Justice Thurgood Marshall of the Supreme Court has advised those who come under pressure by militants to "stand up and say, 'Look man, you do what you want to do and I'll do what I want to do. But, don't tell me I have to do what you want me to do just because you said it.'"

In science, you do your own thing–based on the data collected. However, what do you do with the data?

Let's imagine that you have collected data from an experiment. You have even made graphs of the data. The big question is, how do you interpret the data? What does the information mean?

A. WILL YOU LIVE PAST 70?

Data are needed before you can draw a graph. Table 1 contains data that tell you the average length of life for anyone born in the United States since 1900.

TABLE NO. **1**

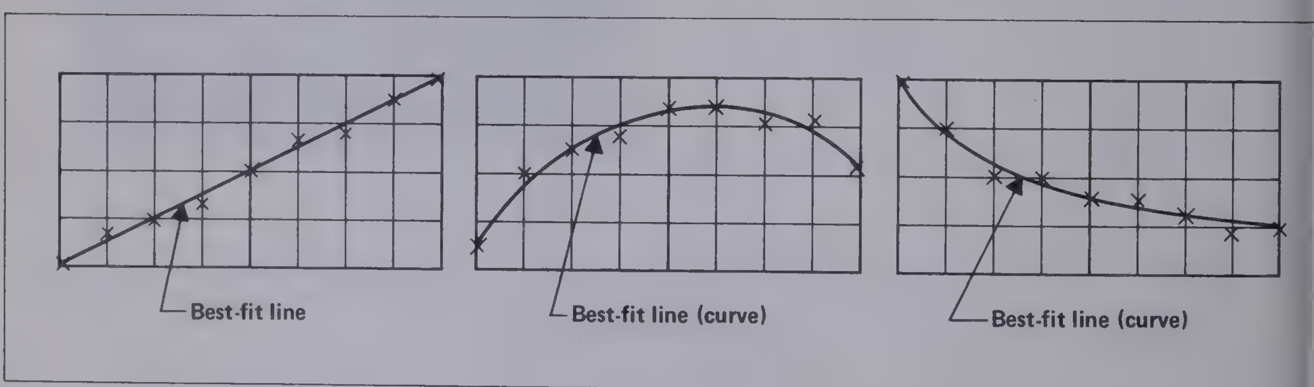
YEARS OF LIFE EXPECTED AT BIRTH

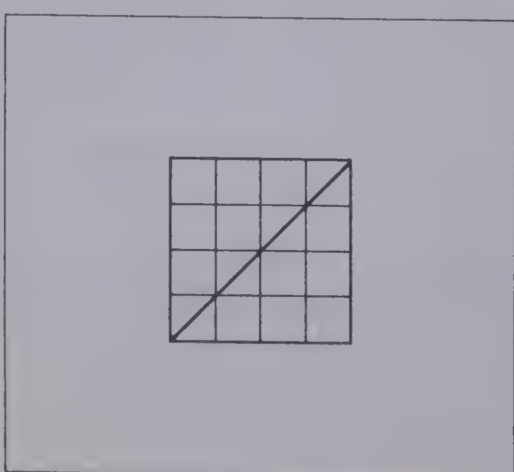
Year	Total	Male	Female	Year	Total	Male	Female
1967	70.5	67.0	74.2	1935	61.7	59.9	63.9
1966	70.1	66.7	73.8	1930	59.7	58.1	61.6
1965	70.2	66.8	73.7	1925	59.0	57.6	60.6
1960	69.7	66.6	73.1	1920	54.1	53.6	54.6
1955	69.5	66.6	72.7	1915	54.5	52.5	56.8
1950	68.2	65.6	71.1	1910	50.0	48.4	51.8
1945	65.9	63.6	67.9	1905	48.7	47.3	50.2
1940	62.9	60.8	65.2	1900	47.3	46.3	48.3

Courtesy 1969 World Almanac.

The table will be easier to see if the data are plotted on a grid and a line is drawn for each sex. Put the points for the line graph in Graph 1 on your data sheet.

Connect the points in Graph 1 with a "best-fit" line. A "best-fit" line is smooth and goes through or close to as many points as possible. A "best-fit" line should have about the same number of points on each side of the line. Some examples of "best-fit" lines are shown below.

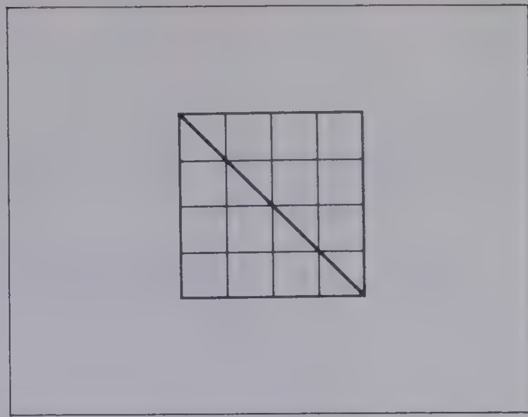




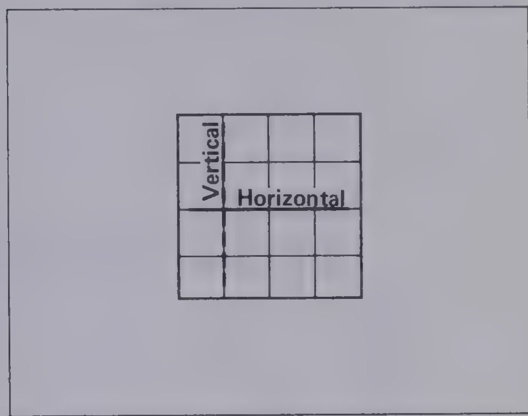
The direction of the line on a graph can give you a picture of what is happening.

1. Suppose a straight line goes upward to the right. This tells you that as one factor increases, the other __?__

2. Suppose a straight line goes downward to the right. This tells you that as one factor decreases, the other ___?___



3. Suppose there is one straight line, either horizontal or vertical. This shows that as one factor changes, the other ___?___



Now that you have some understanding of how to read a graph, refer to Graph 1.

4. From the graph, find the life expectancy of a female born in 1945.

5. Who should live longer, a male or a female born in 1950?

Graphs not only summarize data, they also help you to make predictions. Sometimes you can make predictions of data that are not in the original data table.

6. What do you predict is the life expectancy of someone born in 1952?

7. Explain how you used the graph to arrive at your answer to question 6.

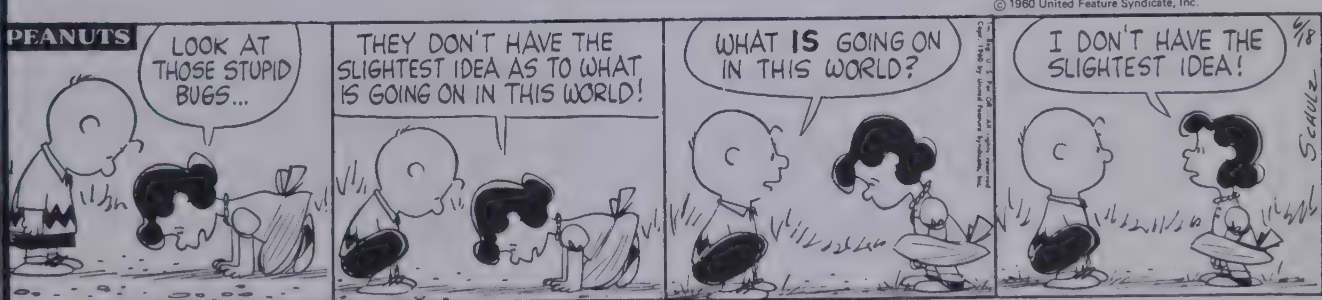
8. What do you predict will be the life expectancy of a female born in 1980?

9. Do males or females live longer?

10. What does the trend show about the life expectancy of females as compared to males?

B. CAN YOU PROVE IT?

Do you believe everything you hear? Are you guilty of making statements that neither you nor anyone else can prove?



You will be given a set of statements. Read each statement and study the graphs on this and the next page. Place the letter a, b, c, d, or e after the statement number (in your data sheet) using the following as a key.

a. The statement is definitely true based on the data shown.

b. The statement is not shown by the data, but it is probably true.

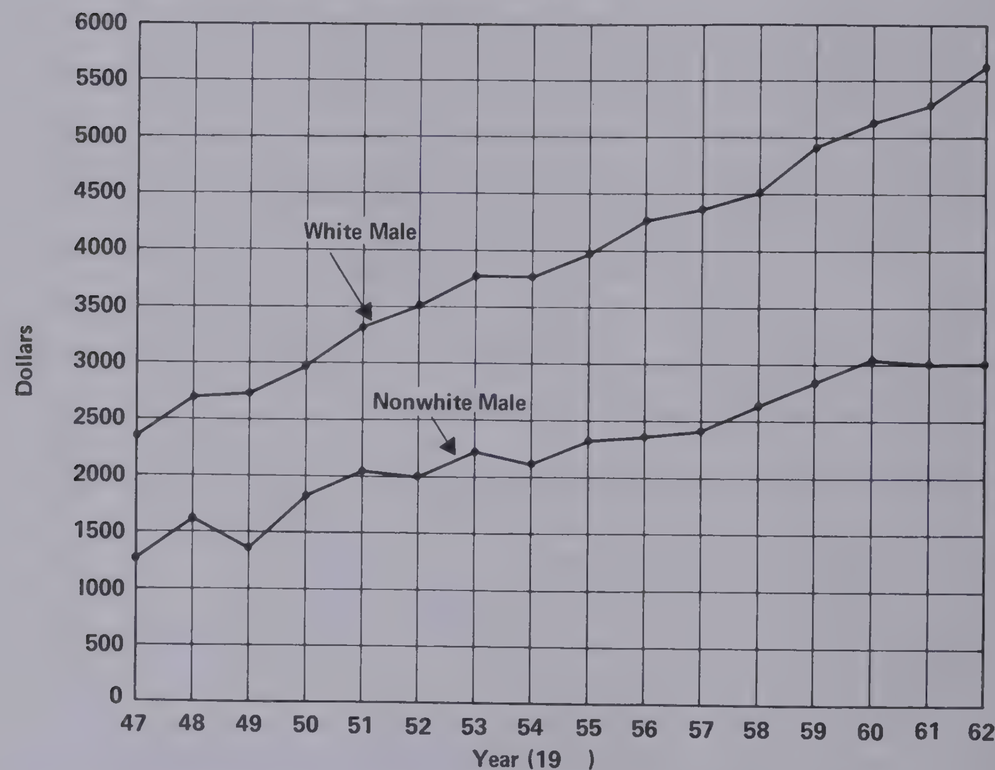
c. The information does not show if the statement is true or untrue.

d. The statement is not shown by the data, but is probably untrue.

e. The statement is definitely untrue based on the data shown.

GRAPH NO. 2

MEDIAN INCOME OF WHITE AND NONWHITE MALE WAGE AND SALARY WORKERS, 1947-1962



11. White males earned more than nonwhite males between 1939 and 1967.

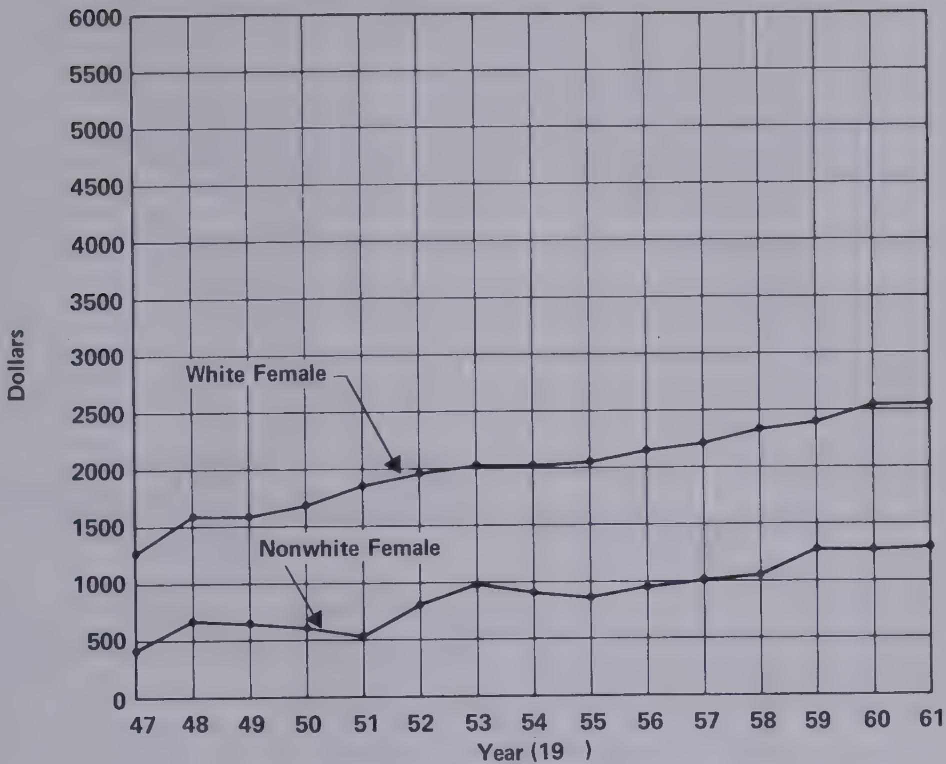
12. A nonwhite male earned about $1,000 in 1944.

13. Nonwhite males earn less because they are poor workers.

14. A white female earns more than a nonwhite male.

GRAPH NO. 3

MEDIAN INCOME OF WHITE AND NONWHITE FEMALE WAGE AND SALARY WORKERS, 1947-1961



15. The gap between the earnings of white and nonwhite males has been slowly closing.

16. Nonwhite males have shown a gain in earnings every year between 1939 and 1962.

17. A white male will earn $7,000 in 1980.

18. A white female earns more than a nonwhite female.

C. GO SOAK YOUR SEEDS

You will be given five radish seeds and five okra seeds. Both kinds of seeds are about the same size.

Weigh all five radish seeds and then all five okra seeds. Construct the framework for a table to record these data in space *a*.

After weighing the two groups of seeds, put them together in a container full of water. Set the container aside for one day.

19. What do you predict will happen to the weight of the seeds overnight?

The next day, blot the seeds dry and reweigh each group separately. Record these data in your table. Study the data and see how many of the following questions you can answer. If there is not enough data to answer the question, write in "not enough data."

20. Which kind of seed increased in weight the most?

21. Which kind of seed increased in weight the least?

22. What probably caused the increase in weight?

23. Explain why corn seeds increase in weight faster than radish seeds.

24. Will the increase in weight continue for one week?

25. If a seed increased in weight, does this mean that it will grow into a plant?

26. If the seed did not increase in weight, what might have been the reason?

D. ARE YOU CAUTIOUS NOW?

Have you ever said something you were sorry for later? Can people influence you easily? Do you believe what others say without asking for proof? Can you do your own thing?

27. What does a scientist do if he does not have sufficient data?

28. What does a scientist do before he draws a conclusion?

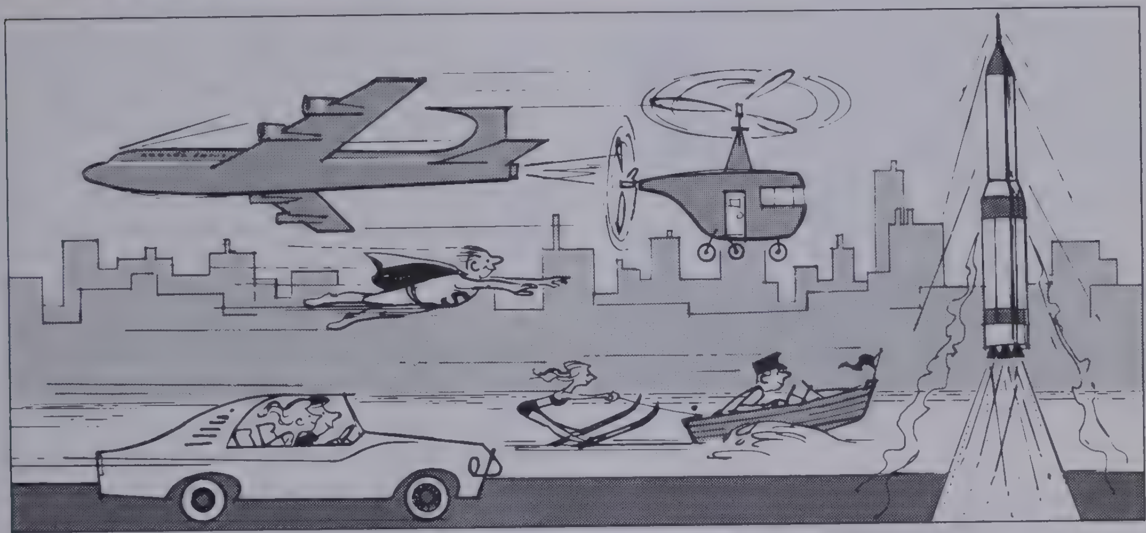
CONCEPT SUMMARY.

Investigation 9

If It's Happening, Baby, It's Happening to You

Do you have the feeling the world is passing you by? Have you ever gone job hunting and found that work for unskilled labor is hard to get?

"You Have to Keep Running Just to Stay in Place" (From *Alice in Wonderland*)



Here is a photo of a library. You will find a library of this type in all colleges, universities, research institutions, and industry. They are called *technical libraries.*

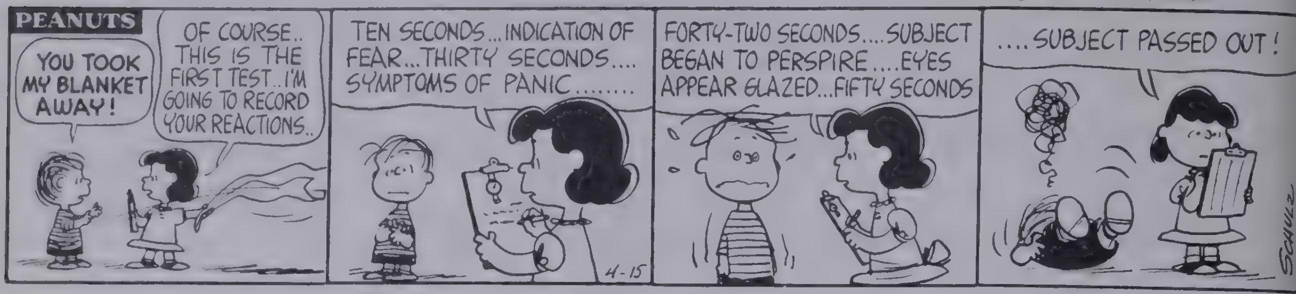
Esso Research & Engineering Co.

A Technical Library

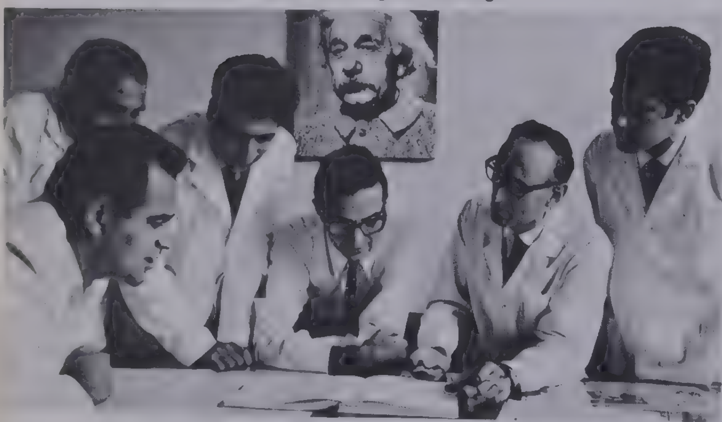
A technical library is where the products of science are stored. That's right, the products of science are not pills, artificial hearts, or better fertilizers. Information is the product of science.

When a scientist finishes an investigation, he writes an account of his work. He then submits it to one of the nearly 100,000 scientific magazines that are published throughout the world. These magazines are called *journals.*

Scientists of every nation contribute their new knowledge. They speak a common language that goes beyond skin color, political beliefs, or national origin. They are only interested in one thing–finding out more about the world through orderly investigation.



Scientists Sharing Knowledge



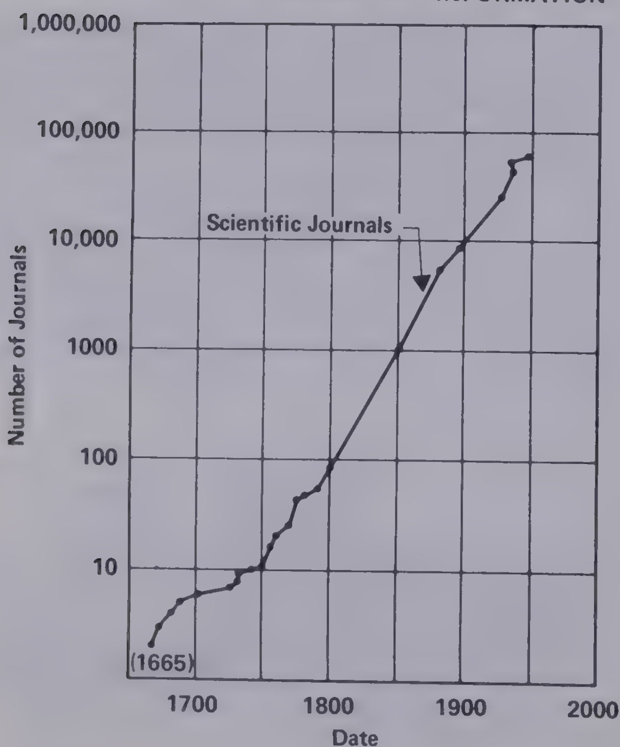
United Nations

Nine out of ten scientists who have ever lived are living today. Since you started reading this investigation enough new information has been published to fill one book the size of an encyclopedia. It would take you about a year and a half to read just one day's output.

Scientists are finding out so many new things that the amount of new information doubles every eight years. Do you know that in many communities there are more students going to night school than day school?

What will happen to those who barely manage to get out of high school? Yes, you truly have to keep running just to stay in place today!

GRAPH NO. 1 THE INCREASE OF SCIENTIFIC INFORMATION



A. YOU'RE ON YOUR OWN

The time has come for you to make some of your own discoveries. Science is something you must discover for yourself. No one can show you, tell you, or sell you.

"He who proves things by experience increases his knowledge; he who believes blindly increases his errors." *Confucius*

Here are two suggested problems.

What would happen if you were to place a bug in the center of a long tube that is wet at one end and dry at the other end? In a tube like the one that is pictured, place wet cotton at one end and a chemical that dries air at the other end. Let the tube sit overnight before placing the bug in the tube.

Kensington Scientific Corp.

You may be familiar with the word starch. If you worry about your weight, you probably know the word. There is a very simple test used to determine if a food contains starch. Two to three drops of iodine are added to a food. If a blue-black color appears, starch is present.

Starch-Containing Foods

National Dairy Council

If you choose to tackle this problem, you should ask yourself these questions. What is the control? Will it matter if the food is solid or liquid? Will cooking affect the food? Which foods will you test?

If you don't like the two problems suggested, come up with one of your own. Maybe your teacher has one of his own.

When you finish your experiment, write a report describing how you solved the problem. You will be doing what a scientist does after he solves a problem.

The form that a scientist uses to write his report can be rather formal and structured. The report has a very definite function. This is how a scientist communicates to other scientists.

To assist you in setting up the experiment and reporting your results use the following outline.

1. *Problem:* What are you trying to find out?

2. *Prediction:* What do you think the answer will be?

3. *Materials Used:* What do you plan to use?

4. *Procedure:* How do you plan to conduct your controlled experiment?

5. *Results:* What happened in your experiment?

6. *Conclusion:* Did you predict correctly? What do the data tell you?

Dr. Paul R. Ehrlich

B. AN HONEST WAY OF THINKING

A report written for a journal is not a true picture of how a scientist attacks a problem. The formal report will not contain all the errors or the wrong guesses. It will not show the excitement while waiting for an experiment to finish. And a report almost never shows the frustration of mopping up ruined experiments.

A scientific report is almost like an account of a football game. Only the successful touchdown drives are described. There are no descriptions of the other plays that made the successful goal-line drive possible.

In a football game, the goal is to score a touchdown. The goal in science is to solve a problem. There are many different ways to progress toward the goal in football or in science. There is no one way or method to solve a problem. You have studied some of these methods in the past eight investigations.

All conclusions in science are only tentative answers. All discoveries in science are subject to change. The only thing definite in science is change itself. Dr. Paul R. Ehrlich of Stanford University wrote in his book, *The Population Bomb:*

"Any scientist lives constantly with the possibility that he may be wrong. If he asks important questions, it is possible that some of the time he will come up with wrong answers. Many are caught before they see print; many are found in the scientific literature. I've published a few myself, as some of my colleagues will testify."

Science is an honest way of thinking.

C. THINK IS RELEVANT

Now that you have solved a problem of your own, you have discovered something. Anyone is capable of solving a problem. Often the results achieved are just as good as those discovered by other people called scientists. Science is not something reserved for people with very high intelligence. Science is only a way of thinking. As long as man thinks, he will continue to expand his mind.

There is a cry for relevance in education today. The most relevant thing to learn in school is how to inquire. Inquiry is a method of logical thinking.

When you consider that many of the jobs that will be available in 1980 are unknown today, the person who is more prepared for tomorrow's world will be the person who . . . has a hunger for learning . . . is curious about the unknown . . . can attack a problem in a logical way.

Inquiry is relevant. Inquiry is the method of science. Just as information is the product of science, logical thinking is the method of science.

CONCEPT SUMMARY.

BIOLOGY

Idea 2
Evolution

Investigation 1

You Can't Help but Bump Into One

Where do you live? Do you live in the city? Or do you live in the country? Wherever you live, you will find living things all around.

Bruce Roberts from Rapho-Guillumette

Living things like bighorn sheep can be found on mountains. Others like blind cave salamanders live in caves.

Rue from Monkmeyer Press Photo Service

Bighorn Sheep

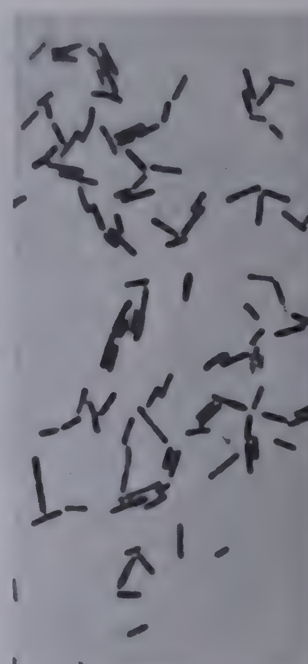
Courtesy of the American Museum of Natural History

Blind Cave Salamander

Living things vary in size. Some are large like this whale. Others are very small like these bacteria.

Whale

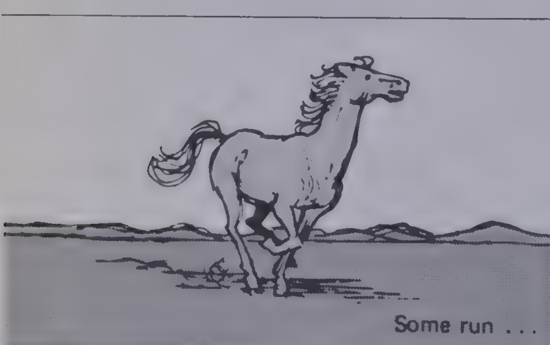
Courtesy of the American Museum of Natural History



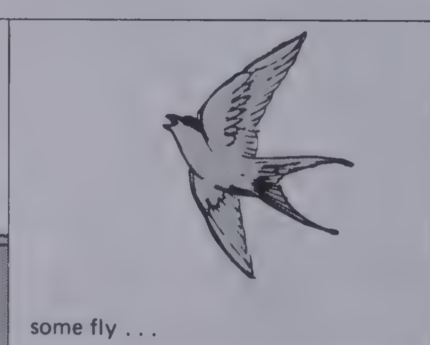
Bacteria

Courtesy Carolina Biological Supply Co.

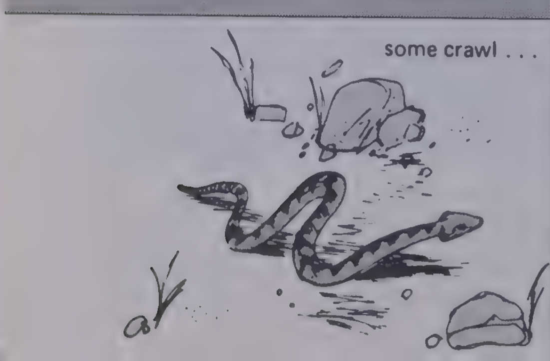
Living things differ in how they move.



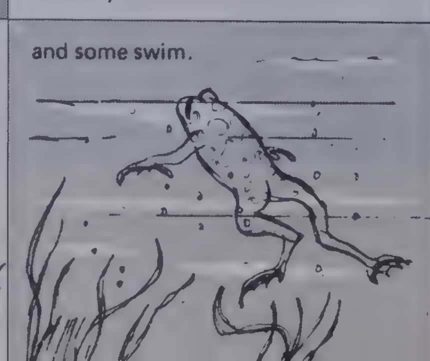
Some run . . .



some fly . . .



some crawl . . .



and some swim.

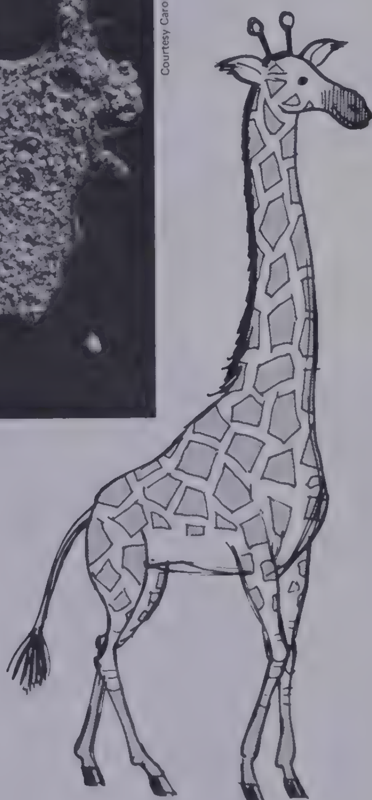
Bruce Roberts from Rapho-Guillumette

Sybil Shackman from Monkmeyer Press Photo Service

David S. Strickler from Monkmeyer Press Photo Service

Courtesy Carolina Biological Supply Co

Ameba



Giraffe

Living things differ in their color. Some are black; some are brown; and others are white.

Living things come in many different shapes and forms. Some living things do not have a definite shape. Others have a very definite shape.

The scientist calls a living thing an *organism*. Ten different organisms are pictured below. Describe each organism in your data sheet. Imagine that you are talking to someone on another planet who has never seen these organisms. Try to give a complete description.

Koala Bear

Australian News & Information Bureau

Fir Tree

U. S. Forest Service

Lobster

Richard S. Vennerbeck from Black Star

Earthworm

Courtesy of the American Museum of Natural History

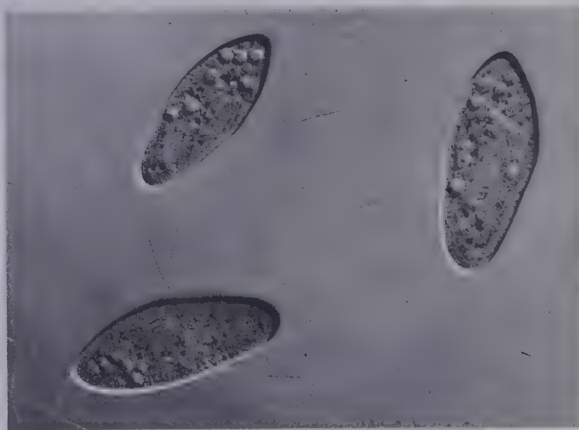
Bat

Canary

Ross E. Hutchins

Spider

Paramecium



Courtesy Carolina Biological Supply Co.

State of Washington Department of Fisheries

Salmon

Rhinoceros

Satour, South African Tourist Group

11. How did you describe all of the organisms?

12. Reread the descriptions. What can you say about each description as compared to all of the other descriptions?

13. What would you predict about the number of different kinds of living things on earth?

14. What general statement might you make about living things?

CONCEPT SUMMARY. (What general concept have you learned in this investigation?)

Investigation 2

Don't Call It Dirt

You call it dirt. You find it in the forest, along the side of a pond, and on the way to school. If you pick it up and look at it, you find nothing moving or growing to indicate life. Is there life in "dirt"?

This investigation is divided into six parts. Each part will be started and then the results will be observed a few days later. During the waiting period, you will complete Investigation 3.

A. A BUG BETRAYER

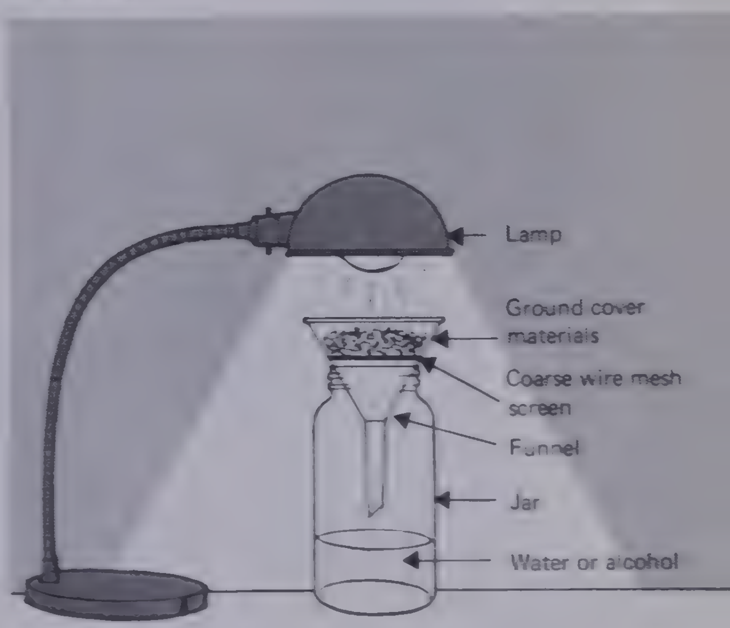
You will be given some leaves, branches, needles, and other materials that cover the ground. This material has been collected from a moist area.

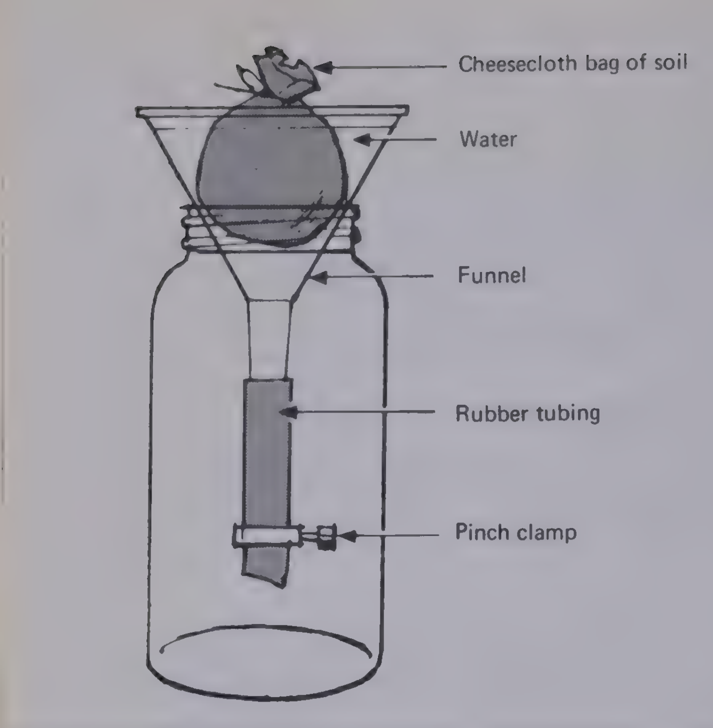
Place some of the material in the funnel of the "Bug Betrayer." Turn the light on.

After 1-2 days, examine anything collected in the jar and make a drawing of each in space *a* of your data sheet.

1. Describe what you see in the jar.

Bug Betrayer





Worm Wangler

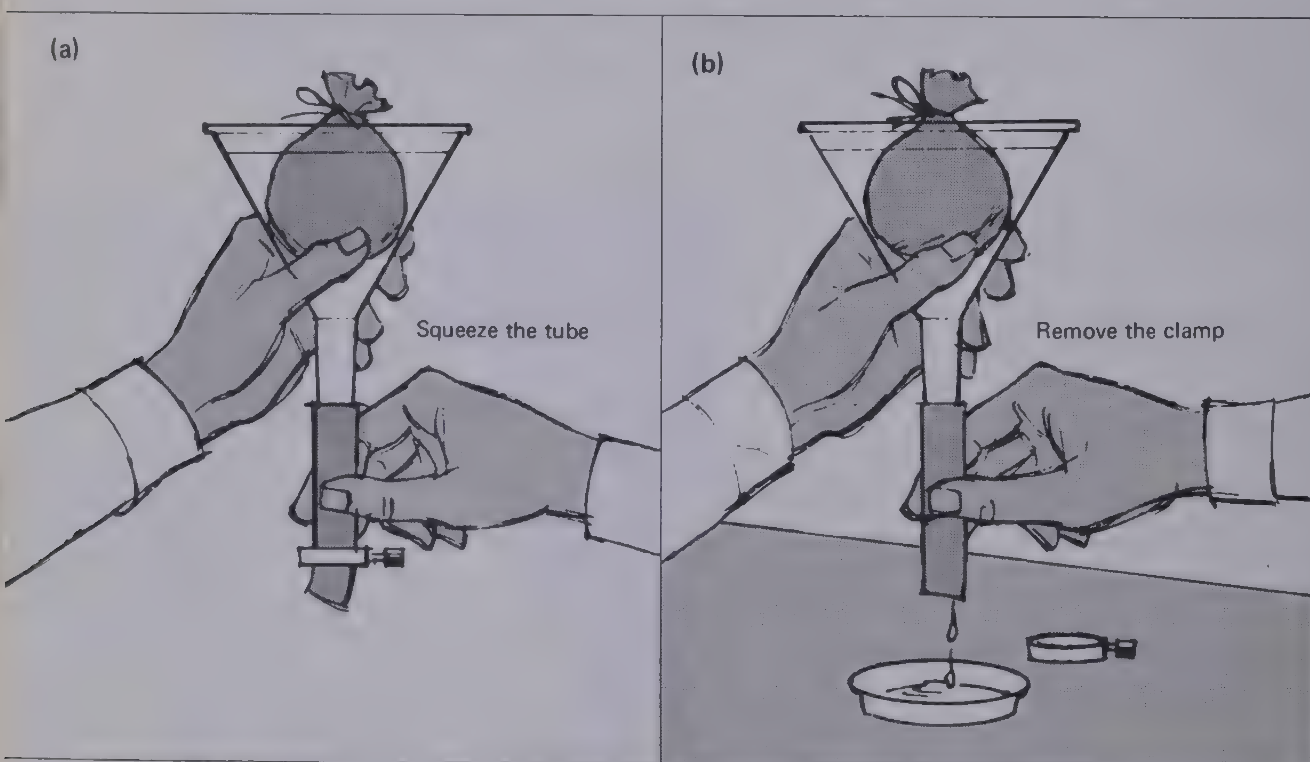
B. A WORM WANGLER

You will be given moist soil which has been scraped from under the ground. Wrap some of this soil in a piece of cheesecloth and place it in the funnel of the "Worm Wangler." Keep the bag of soil covered with water at all times.

If there are any living things in the soil, some of them may drop to the bottom of the funnel after 1-2 days. To find out, hold the "Worm Wangler" above a small dish. Squeeze the tubing an inch above the clamp. Then have your partner remove the clamp to allow the inch of liquid to fall into the dish. Return the "Worm Wangler" to the jar.

Examine a drop of the liquid under the low power of a microscope. Make a drawing of what you see in space *b*.

2. Describe what you see under the microscope.

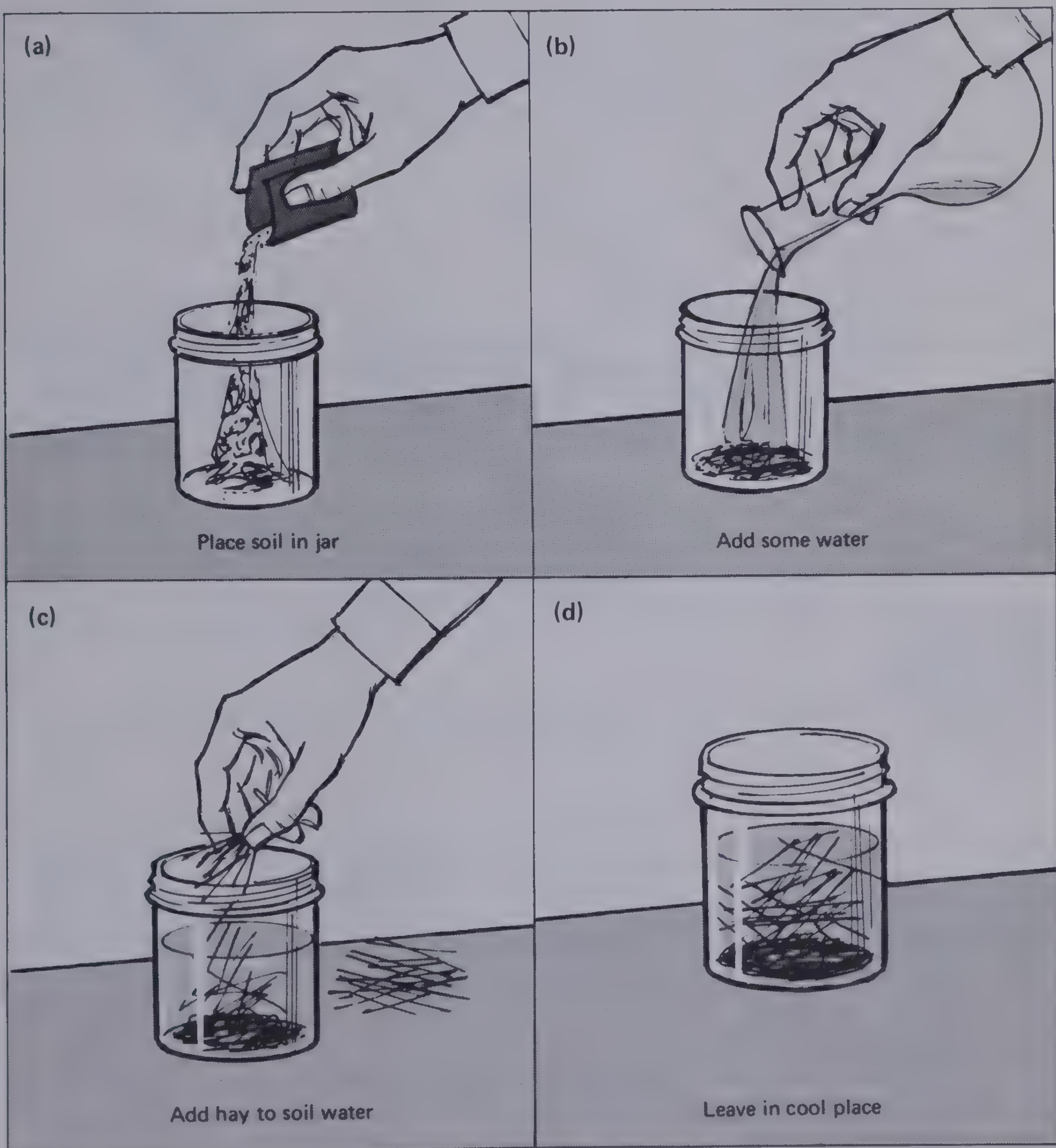


C. WHAT IS A MICROBE?

You will be given some soil and hay for this part. Place some of the soil in the bottom of a small jar. Add water to the jar. Place some of the hay in the water, too. Leave it in a cool, dim place.

After a week, examine a drop or two of the liquid under the low power of a microscope. Make a drawing of the various things that you see in space *c*.

3. Describe what you see.

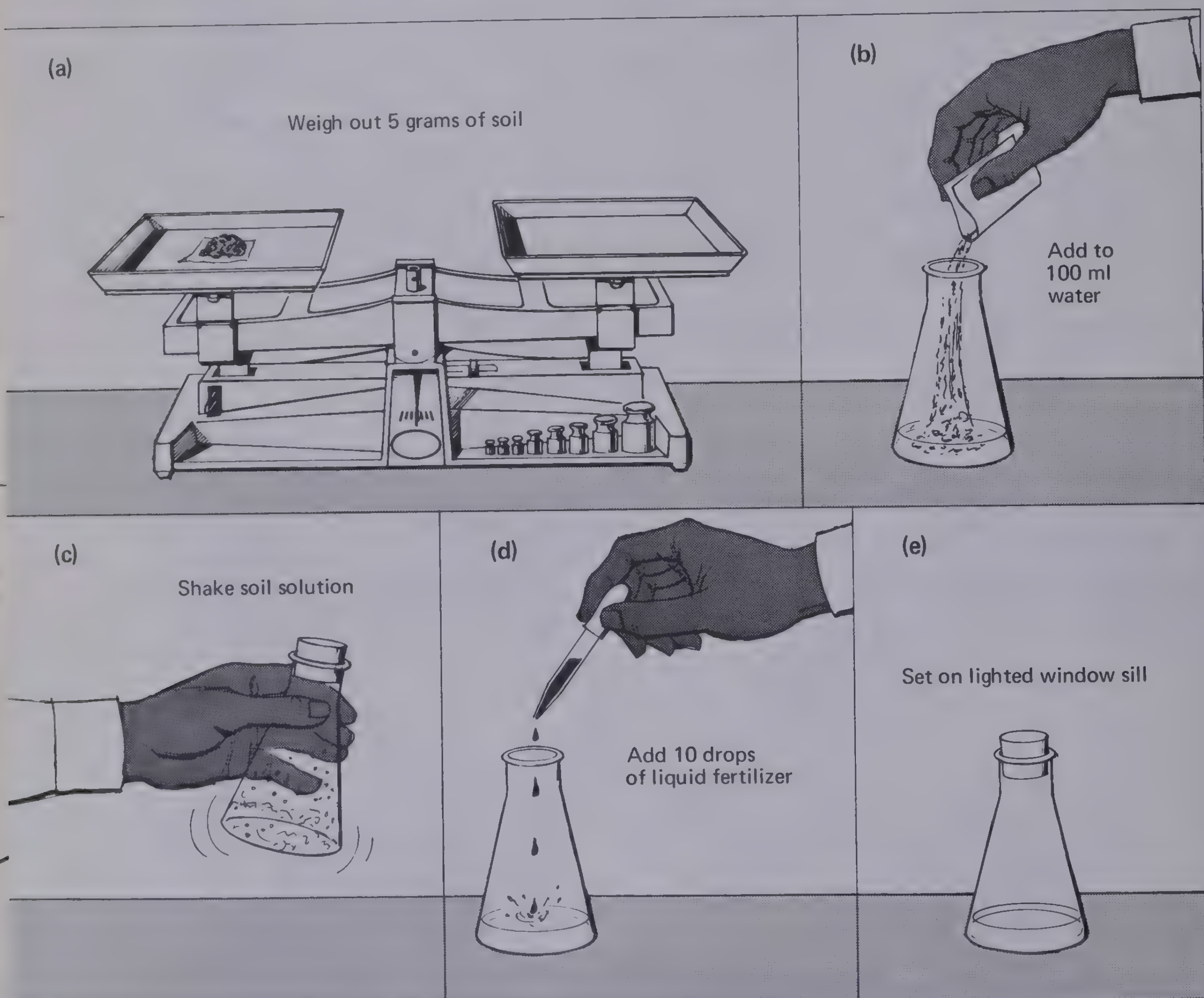


D. ARE MICROBES COLORLESS?

You will be given some soil that has come from a pond. Weigh out 5 grams of soil and add it to 100 ml water in a container.

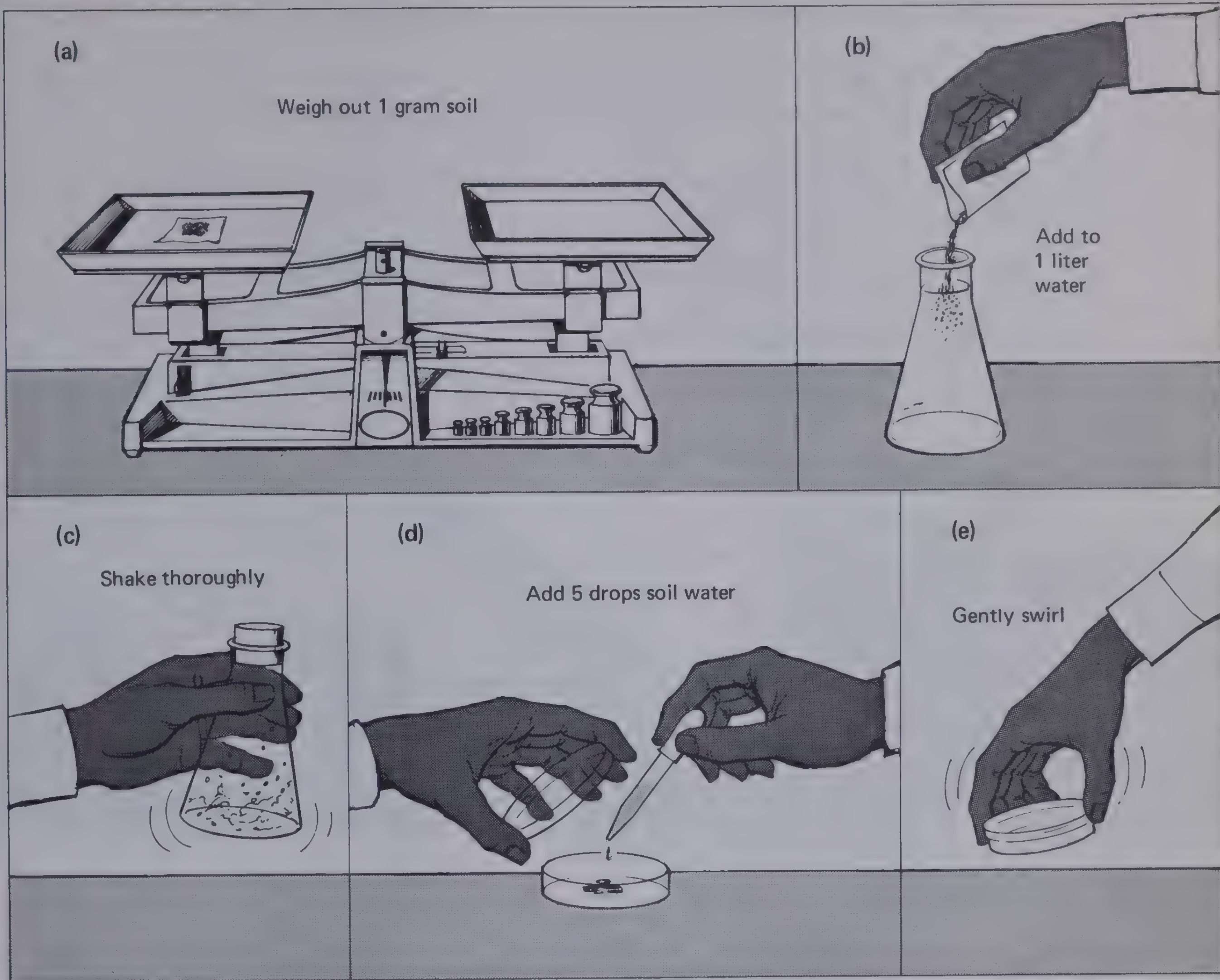
Add 10 drops of liquid fertilizer to the water. Cover and set the container on a lighted window-sill for a few days.

4. Describe what you see.



E. ARE MICROBES FUZZY?

Use the leftover soil from parts B or C. Weigh out 1 gram of the soil and add it to 1 liter of water. Shake thoroughly.



You will be given a Petri dish. It has been sterilized. This means that all life has been killed inside the dish. Therefore, do not open the dish until you are sure of what you are to do.

The solid material in the dish is food for certain microbes. A chemical has been put into the food to prevent microbes other than the ones we want from growing. Red dye has also been added to help you see certain features.

Open the cover of the dish as little as possible. Add 5 drops of the soil water to the dish. Save the remainder for part F. Gently swirl the contents of the dish. Set it in a warm, dark place.

After 4-7 days, examine the dish and make a drawing of what you see in space *d*.

5. Describe the growth in the dish.

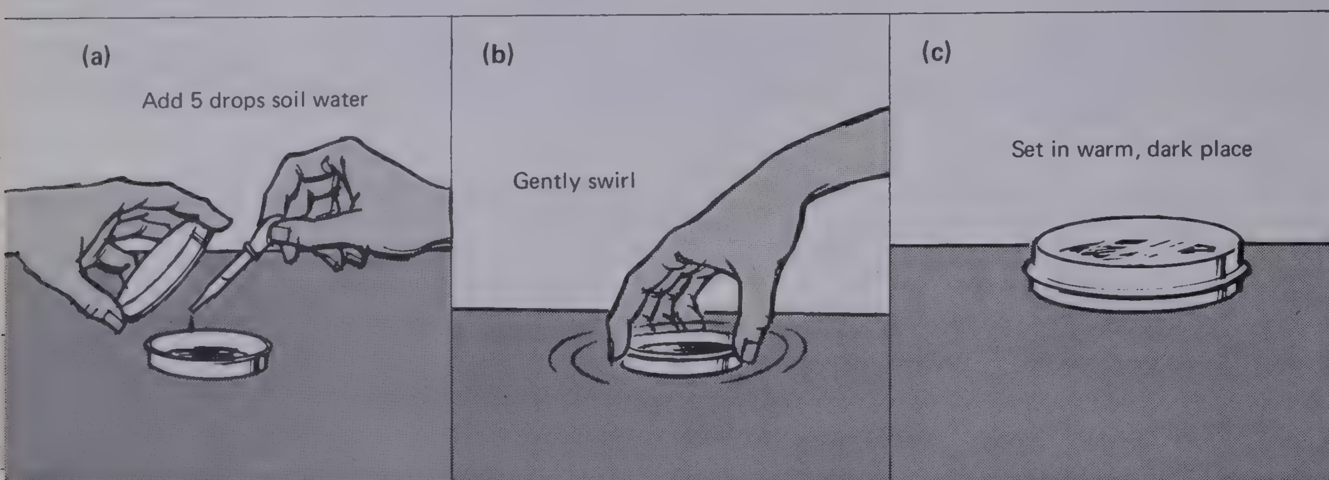
F. ARE SOME MICROBES SHINY AND OTHERS DULL?

You will be given another sterilized Petri dish. A different food is in this dish. This means that only those organisms that will grow on this kind of food will appear.

Add 5 drops of the soil water from part E to the dish. Gently swirl the contents of the dish. Set it in a warm, dark place.

After 4-7 days, examine the dish and make a drawing of what you see in space *e*.

6. Describe the growth in the dish.



G. STILL WANT TO CALL IT DIRT?

If you wish, repeat various parts of this investigation, using soil collected from different locations. Collect and compare your data.

7. What material was tested or examined in each of the six parts of this investigation?

8. If you or your classmates were able to find living things in each of the parts of this investigation, where do you think the living things came from?

9. How many different kinds of living things did you see?

10. What is the difference between "dirt" and soil?

11. What concept did you learn in the first investigation?

12. What general statement can you make about living things and soil?

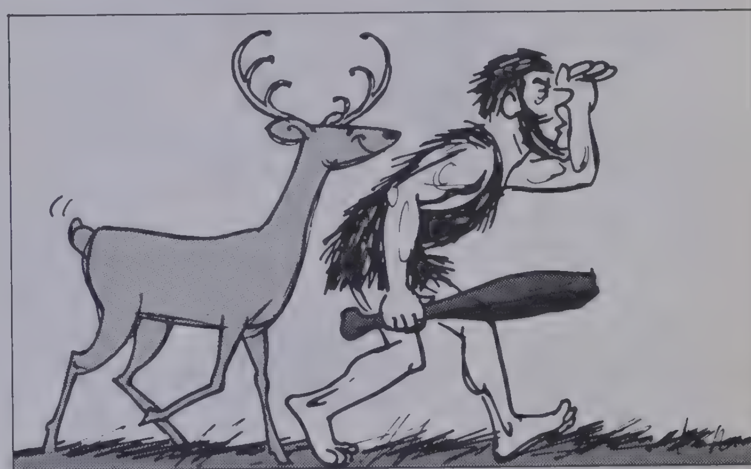
CONCEPT SUMMARY. (What general concept have you learned in this investigation?)

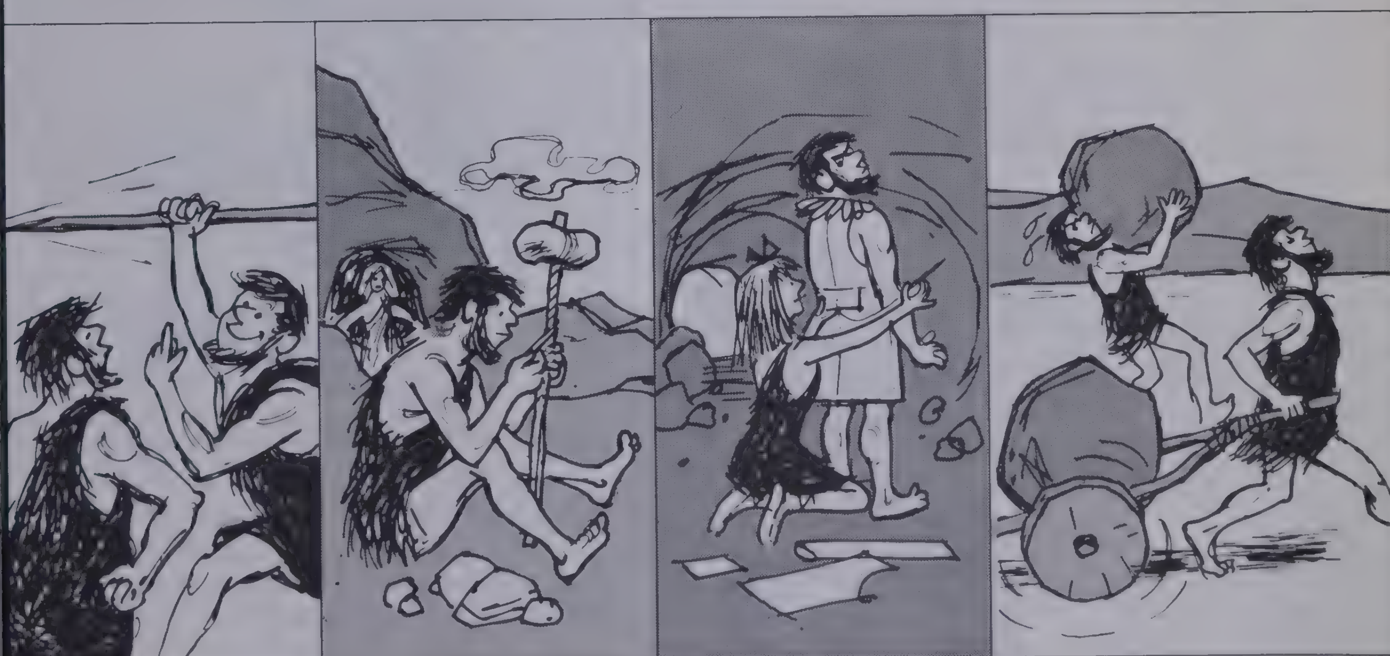
Investigation 3

Human Senses Are So Poor

Since the dawn of history, man has been an explorer. His curiosity has carried him through one discovery after another. But man soon discovered that he had limitations. His senses of sight and hearing were limited. And his sense of smell was often poorer than the other animals'.

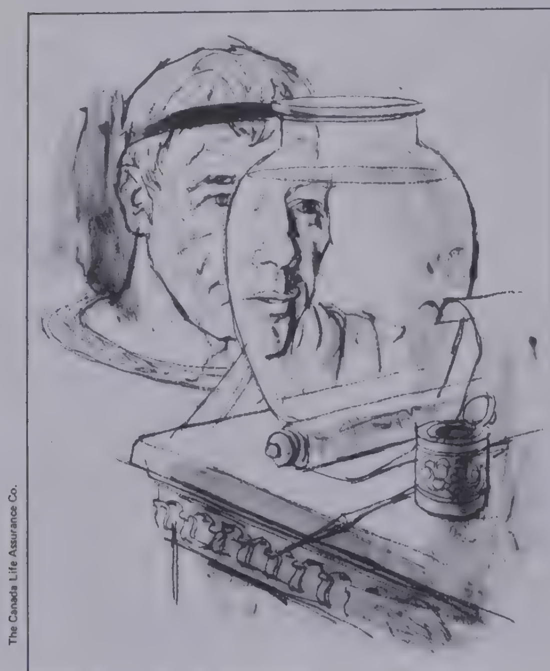
But man learned to overcome his limitations. He shaped sticks into hunting spears and stones into pounding and cutting tools. As man learned to till the soil, to make clothing, and to build shelters, his tools became more and more complex. He devised special tools and instruments to extend his senses.



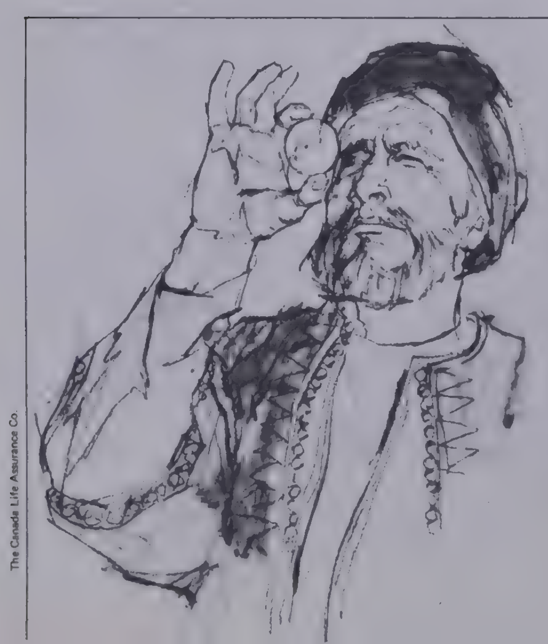


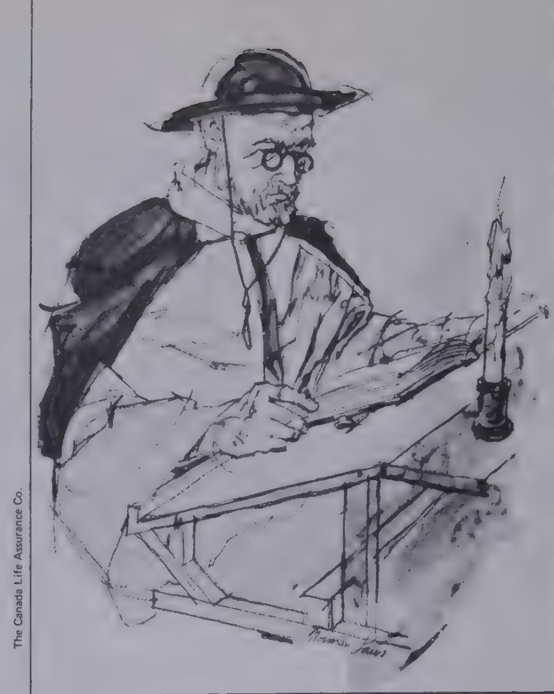
A. HISTORY OF THE MICROSCOPE

a. The microscope had its beginnings centuries ago when the Chinese, the Egyptians, and the Romans discovered that small letters could be read more easily through a glass jar filled with water.

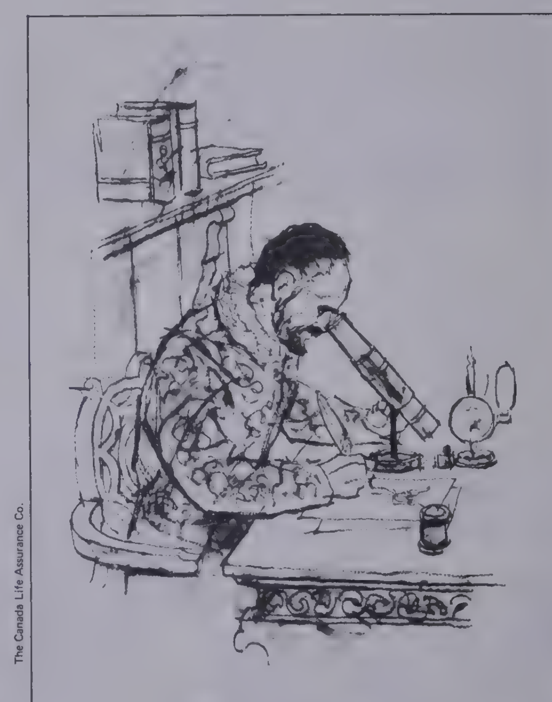


b. During the eleventh century, Near East scholars invented the first lenses that were curved on both sides.

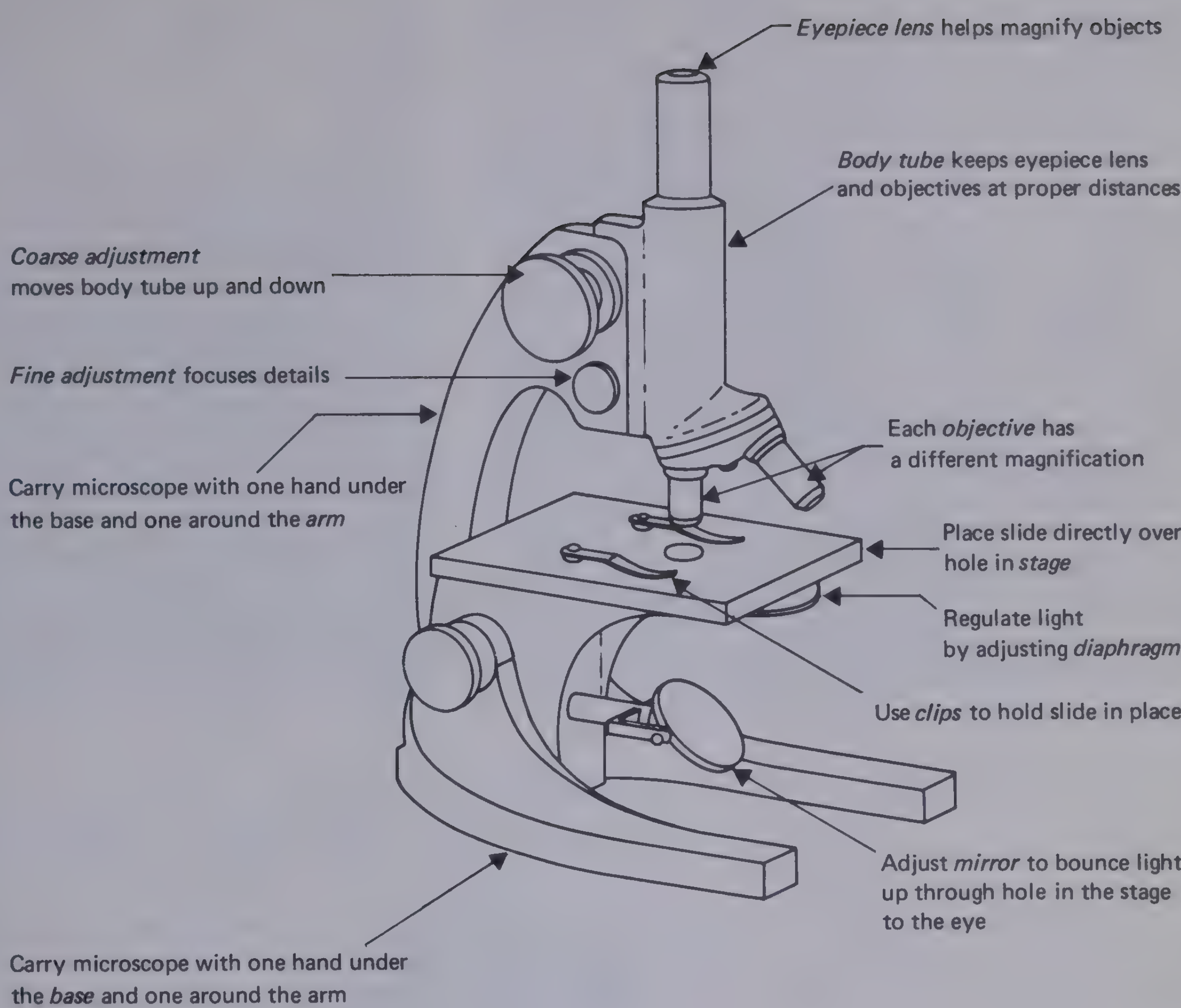




c. By the end of the thirteenth century, "spectacles" were helping people to read.



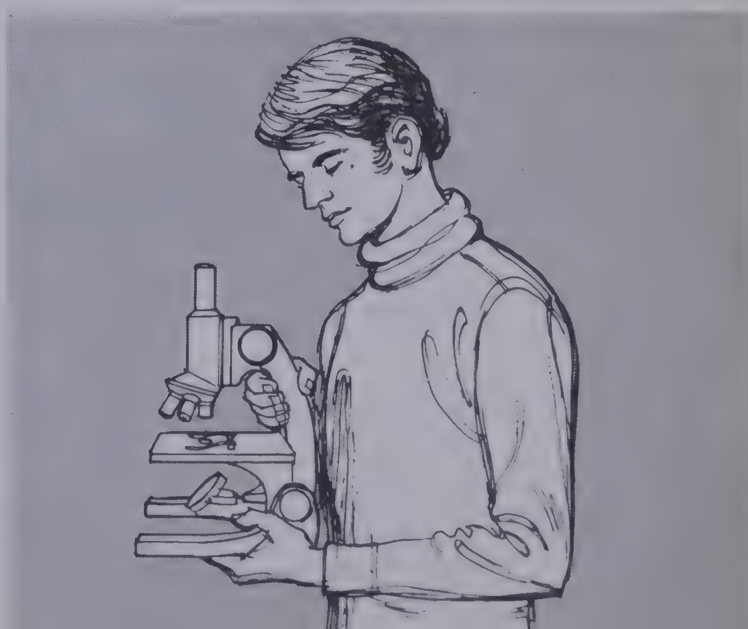
d. Then, in the sixteenth century, two or more lenses were put together and the first compound microscopes were invented. With the microscope, man was able to explore the unseen world in a drop of water.

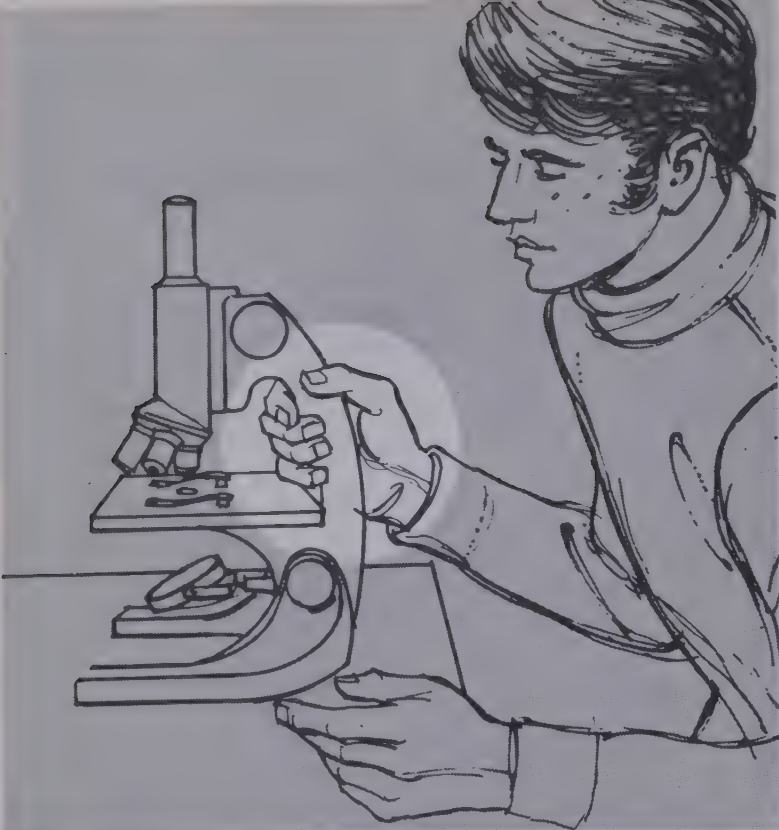


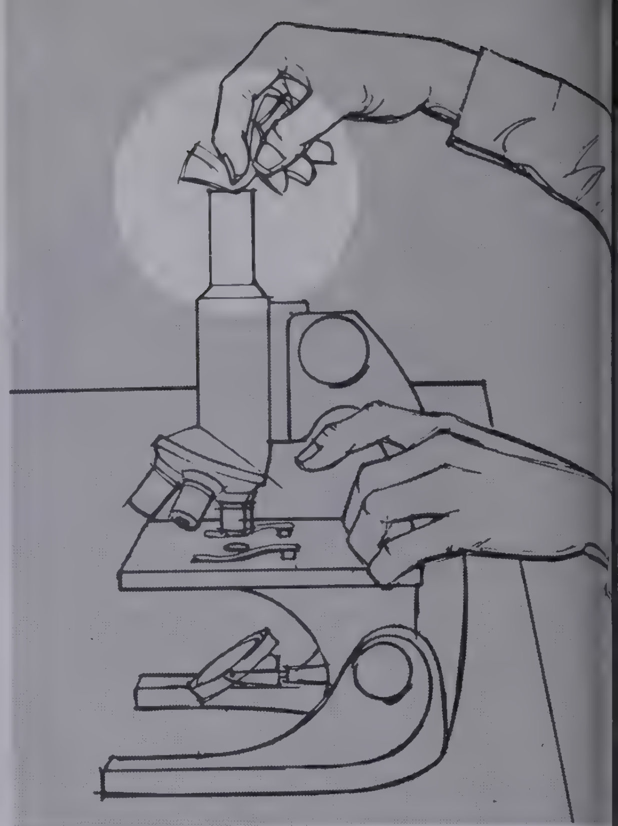
B. CARE AND PREPARATION OF THE MICROSCOPE

The microscope is an expensive and delicate instrument. Treat your microscope with care and it will enhance your sense of sight.

Carry the microscope with both hands, one hand under the base and the other on the arm.







Set the microscope in front of you with the arm nearest you.

If necessary, clean the lenses with lens paper. The lens paper will not scratch the lenses.

The purpose of the microscope is to magnify objects. The magnification of your microscope is printed on the instrument. Look at the eyepiece and you will see a number with an "x" after it. The number is the magnification of the eyepiece. The "x" means "times."

1. What is the magnification of the eyepiece on your microscope?

2. Your microscope may have two or three objectives. What is the magnification of each objective?

To find the total magnification of your microscope, multiply the magnification of the eyepiece by the magnification of the objective in use.

3. What is the lowest magnification or power of your microscope?

4. What is the highest power of your microscope?

In order to see anything, light must reach your eye. While using the microscope, light must reach your eye when you look into the eyepiece.

Turn the objectives so that the microscope is at its lowest power possible. If your microscope has a built-in light, simply turn it on.

5. But if your microscope has a mirror, how will you have to position the microscope and adjust the mirror?

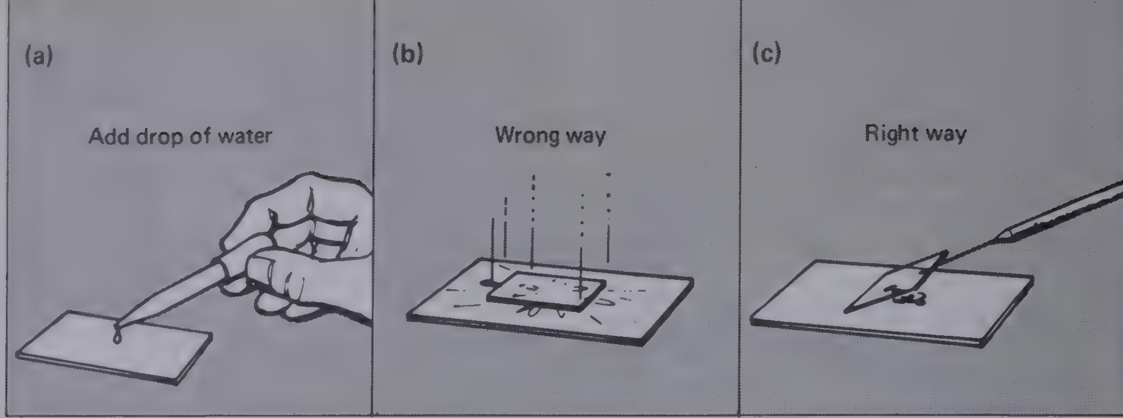
6. Adjust the diaphragm. What happens?

C. PREPARATION OF THE SAMPLE

You are now ready to prepare the sample for viewing. The sample is to be placed on a glass slide and then placed on the stage of the microscope.

7. Do you think you should place a lot or very little of the sample on the slide? Should the sample be thick or thin? Explain.

Cut out a small "e" from the "want ad" section of the newspaper. Place the "e" right side up on a slide. Add one drop of water on the top of the "e." If the letter moves, use a needle to move it back to its right-side-up position. Place a cover slip on top of the drop of water. The water will keep the two pieces of glass together. What you have just prepared is called a *wet mount.*



If you drop the cover slip as pictured above, you will trap air bubbles. If air is trapped under the cover slip, the particles of air and dust will interfere with what you see. Therefore, lower the slip slowly at the angle pictured. This will push the air out the side of the cover slip.

8. What is a wet mount?

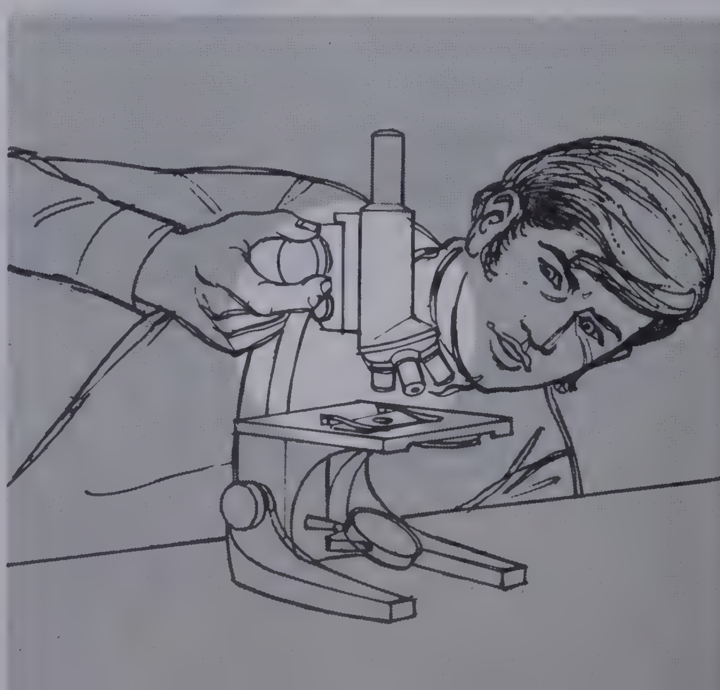
9. Why is water (or a liquid) used in preparing a wet mount?

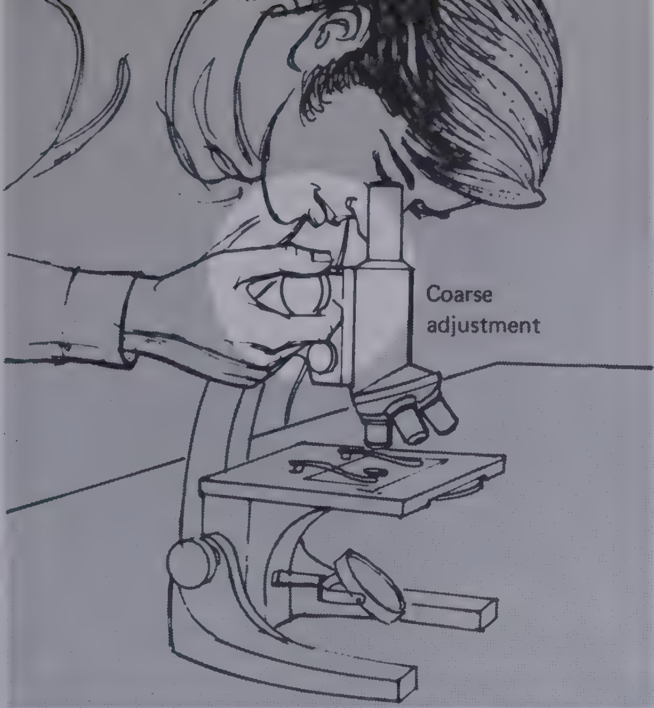
D. ADJUSTING THE MICROSCOPE

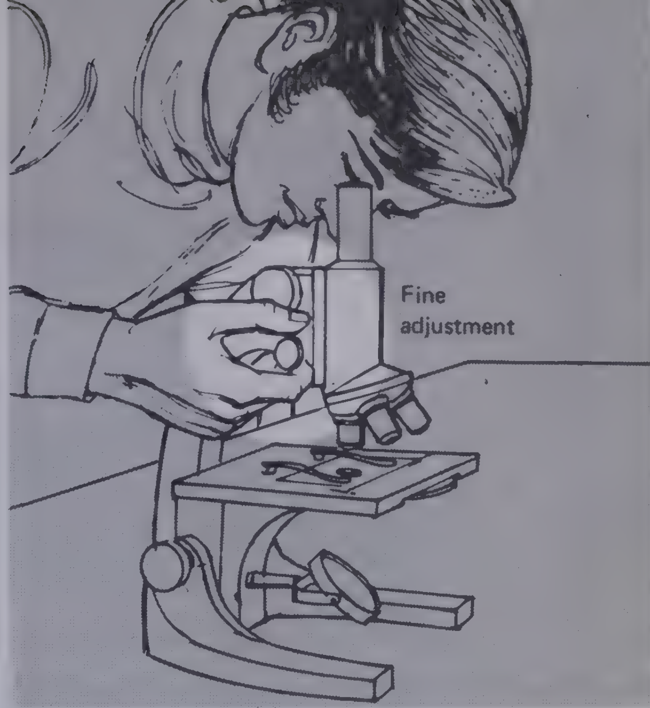
Place the slide you have just prepared directly over the hole in the stage. Use the two clips to keep the slide from moving. Since you are using a wet mount, do not tilt the arm of the microscope.

Many school microscopes have a safety feature which prevents you from accidentally turning the objectives into the slide and breaking the objective lens. If your microscope does not have this safety feature, be very careful when you turn the objectives down.

Looking at the low power objective (usually 10x) *from the side,* lower the objective so that it *almost* touches the slide.







Now, look into the eyepiece and slowly turn the coarse adjustment to raise the tube. The "e" should come into focus. If you turn more than 1-2 cm, start again.

Finish focusing by turning the fine adjustment.

10. In space *a* on your data sheet, make a drawing of the letter "e" as it appeared on the slide before you placed it under the microscope.

11. In space *b*, make a drawing of the "e" as it appears under the microscope. Indicate the magnification of the letter next to the drawing.

12. Raise the tube 1 or 2 cm. Turn the objectives to the next higher power. Focus this objective as you focused the low power objective. In space *c*, make a drawing of the "e" as it appears now. Again, indicate the magnification of the letter.

E. OBSERVING WITH THE MICROSCOPE

13. When you move the slide, which way does the image move?

14. When you switch from a lower power to a higher power, what happens to the image that is at the edge of the field?

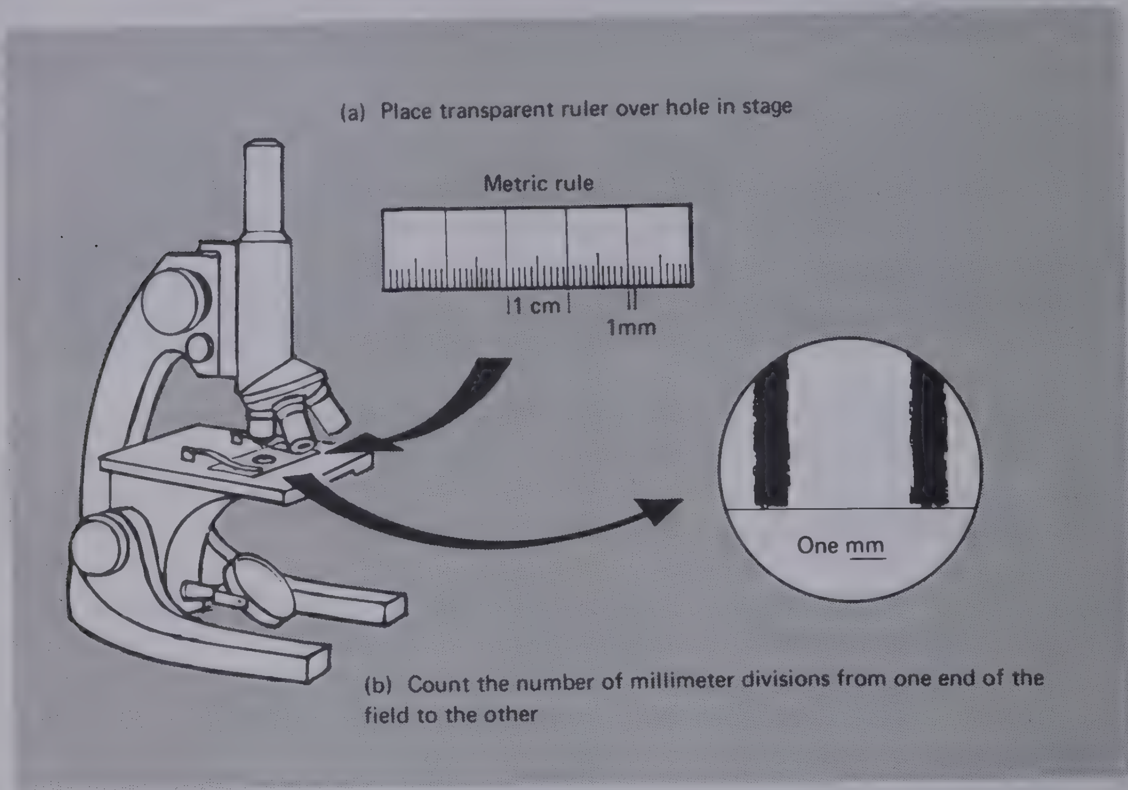
15. Do you see more or less of the object as the magnification is increased? Explain.

16. Most beginners want to use the highest power possible. Experienced students and professional scientists soon learn to use low power most of the time. Why?

17. Adjust the diaphragm. Should you always use the largest opening? Explain.

F. MEASUREMENTS USING THE MICROSCOPE

The *field* of the microscope is the lighted circle you see when you look into the microscope. The diameter of the field can be measured by focusing your low power objective (10x) on the edge of a plastic ruler.



18. What is the diameter of the field under low power?

Once you know the diameter of the field, you can easily estimate the size of an object. For instance, if an object covers half of the field, it is one-half the diameter.

19. Make a wet mount and measure the following: (a) strand of your hair; (b) sand crystals.

When you are finished, you should:

a. clean and dry the slides

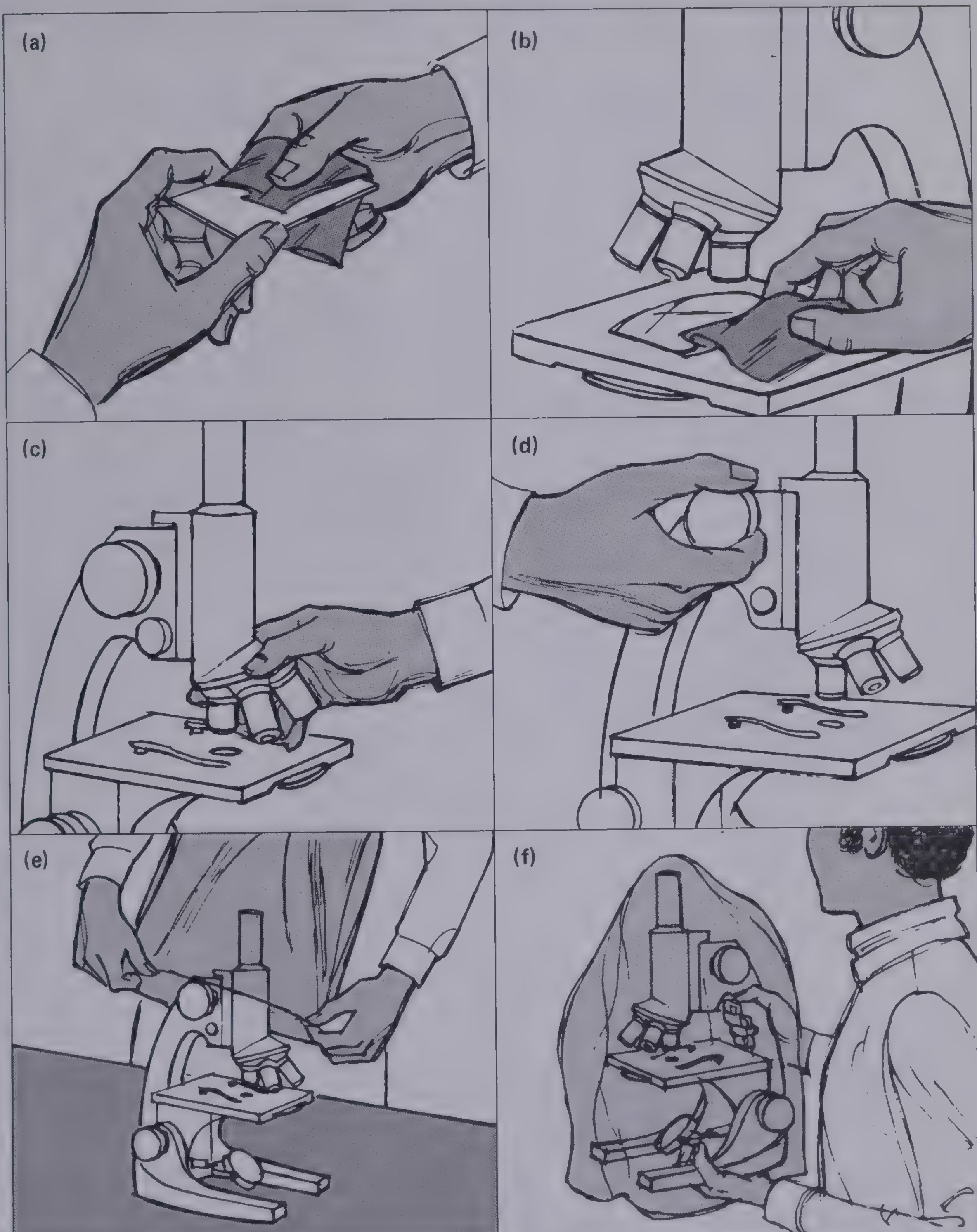
b. clean and dry the stage, and clean the lenses with lens paper

c. return the objective to low power

d. turn the tube down to within 1 cm of the stage

e. cover the microscope

f. hold the microscope with both hands when returning it to its proper location.



You now know how to use the microscope, an instrument used to extend the sense of sight. Treat it with care. The microscope will help you to see things you have never seen before.

CONCEPT SUMMARY. (What general concept have you learned in this investigation?)

Investigation 4

What's So Complicated About Water?

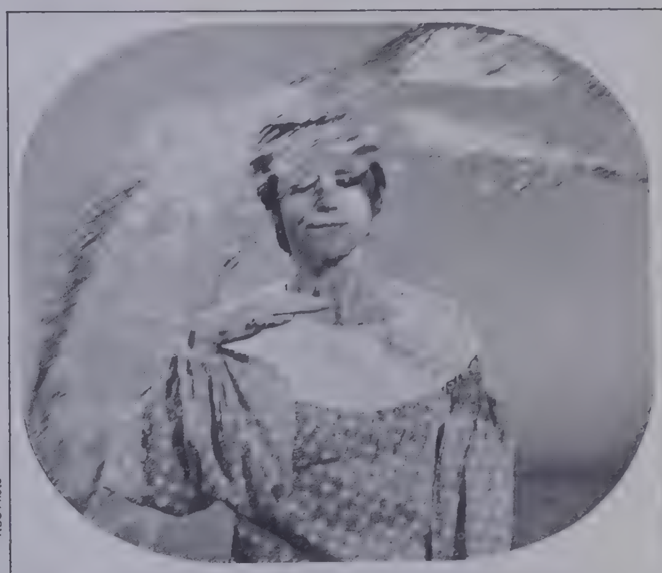
By now you have studied that there are many different kinds of living things on this earth. You also discovered that living things are found in some very unlikely places, like a handful of soil. And finally, you learned that the microscope can extend the sense of sight.

Water, water everywhere, so much that we take it for granted–until we pollute it or use it unwisely. Then we realize how important water is to the maintenance of life. All life is dependent on water.

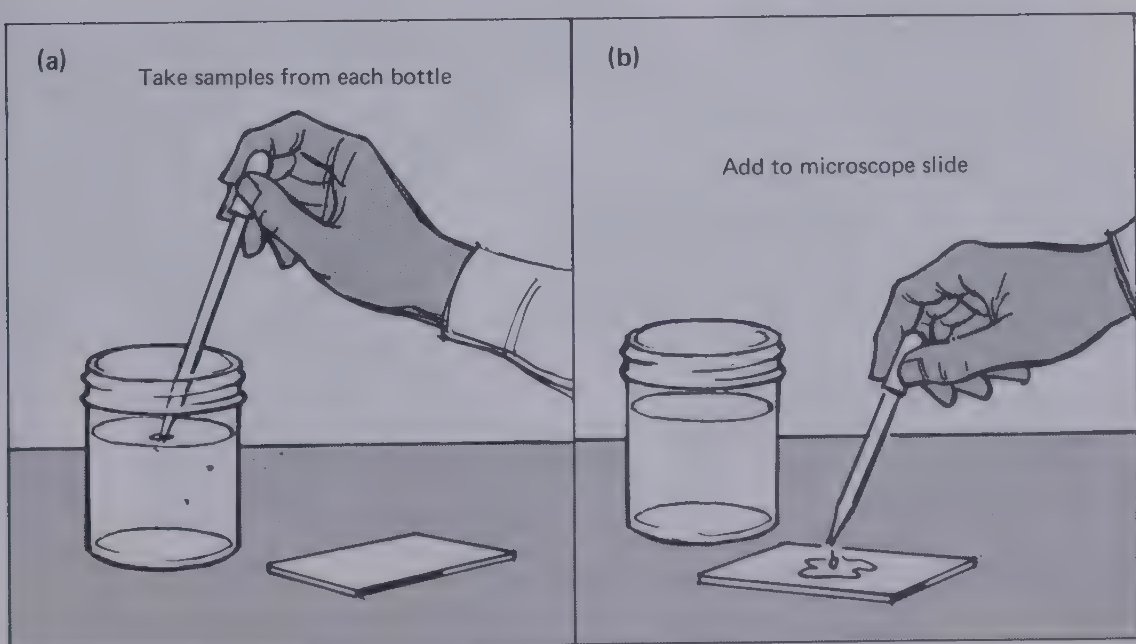
Hold up some pond water and look at it. How can anything like pond water be complicated? How can anything as common and simple as water be complicated?

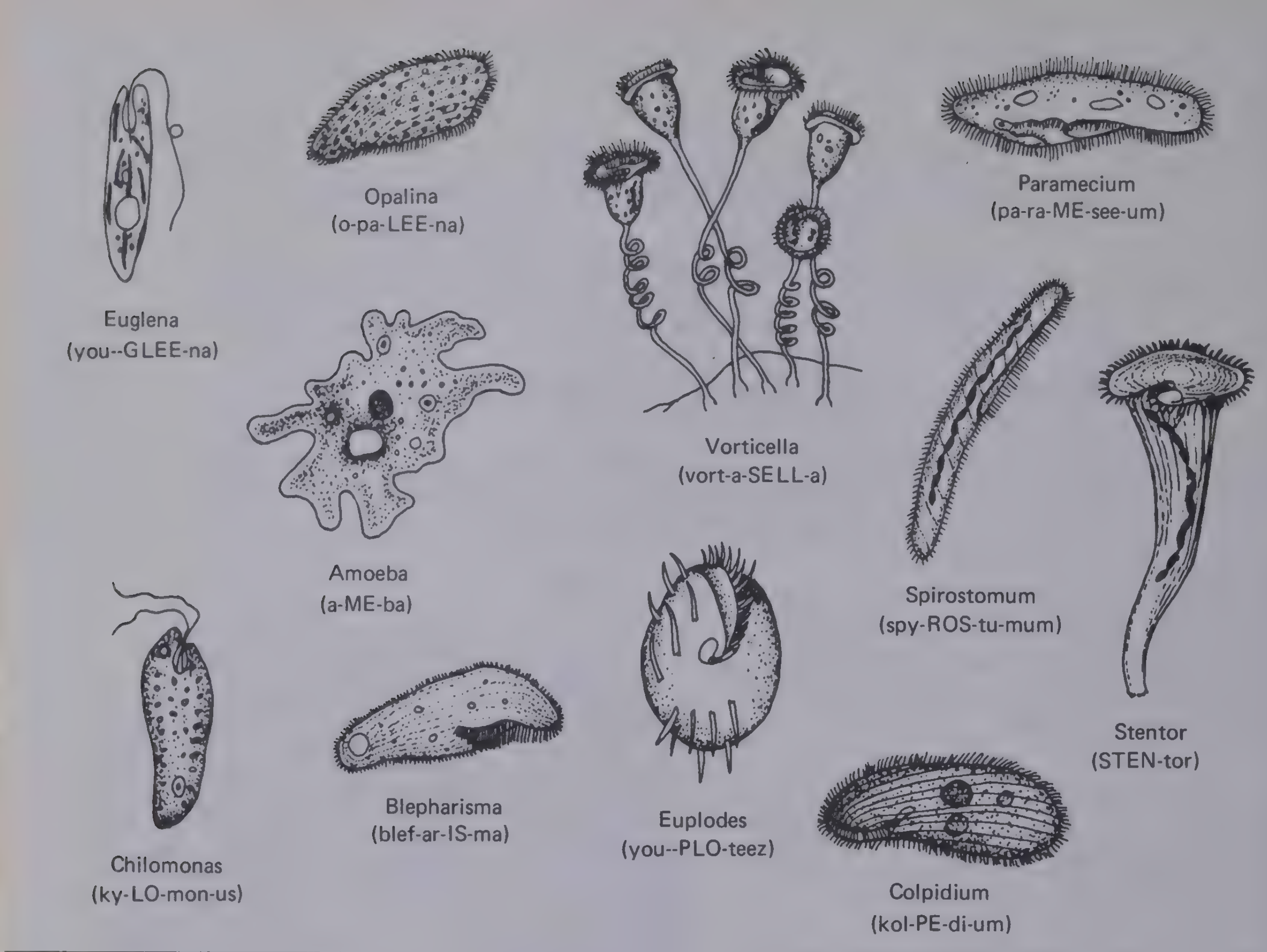
Samples of pond water are scattered around the room. Take a drop of water (one at a time) from each bottle and observe it under the microscope. Take different samples from each bottle. Try a drop from the bottom, the top, and the middle of the bottle.

"Sock It To Me!"



NBC Photo





If the field of your microscope is too bright to see the details, reduce the amount of light coming through the diaphragm. You may also want to try a drop of stain.

Make neat, accurate drawings of everything you see. Try to identify each organism by referring to the drawings.

Make your drawings in space *a* on your data sheet. If you can identify the organism from the illustrations, place its name under your drawing. Indicate the magnification under which you observed the organism.

Study all of your observations and drawings. Then answer these questions.

1. Were there many or few different kinds of living things in your pond water sample?

2. What general concept about living things have you been developing in the past few investigations?

3. What general statement can you now make about living things in water?

CONCEPT SUMMARY.

Investigation 5

All Men Are Created Equal

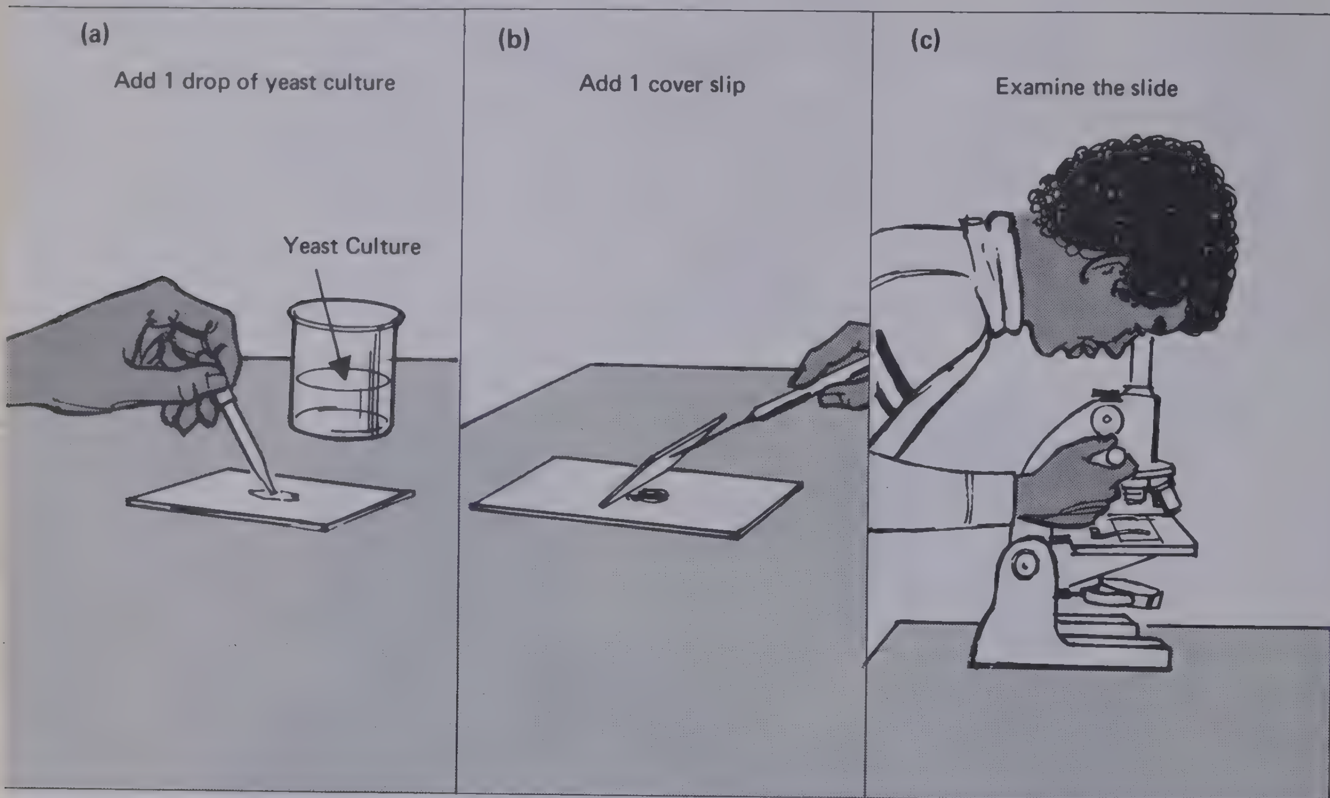
Would you believe these two boys have something in common? What is it?

Would you also believe that all living things have something in common? Let's try to find out what they have in common.

Suzanne Szasz

A. WHAT LOOKS LIKE A FOOTBALL?

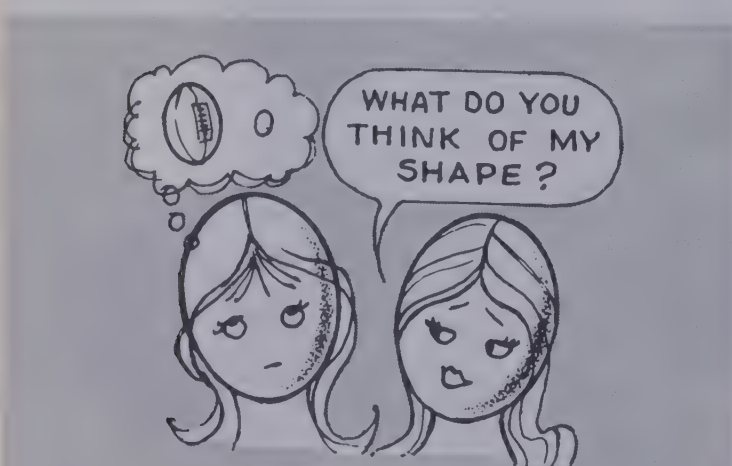
You will first be given some yeast. Yeast is a microscopic plant which is used in baking and brewing. Put 1 drop on a slide and place a cover slip on it. Examine the yeast under the microscope.



Make a drawing of what you see in space *a*. There is no need to draw each yeast plant.

Notice that each yeast plant has the shape of a football or egg. There is an outside covering called the *cell wall.* The region inside is called the *cytoplasm.* Label the cell wall and cytoplasm in one of the yeast plants.

1. What do you think this labeled structure or unit is called?

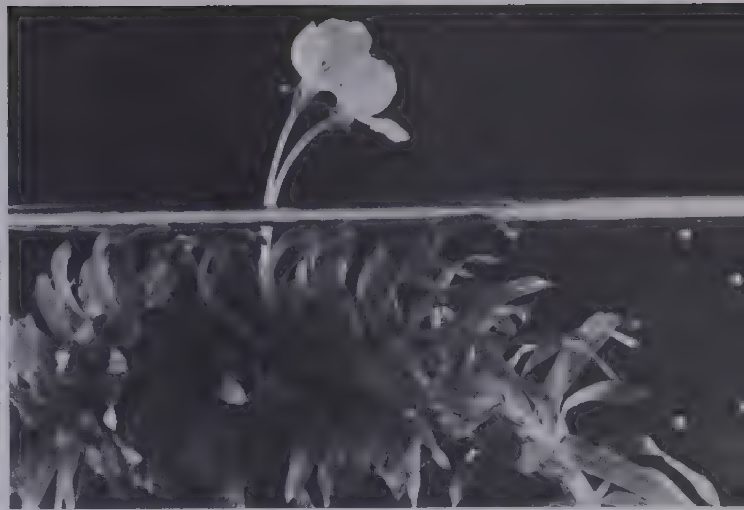


One yeast cell to another

B. WHAT ARE LITTLE PLANTS MADE OF?

Make a wet mount of a leaf of Elodea, a common aquarium plant.

Draw a section of what you see in space *b*. There is no need to draw the entire field. Make your drawing large.


Courtesy Carolina Biological Supply Co.

Elodea

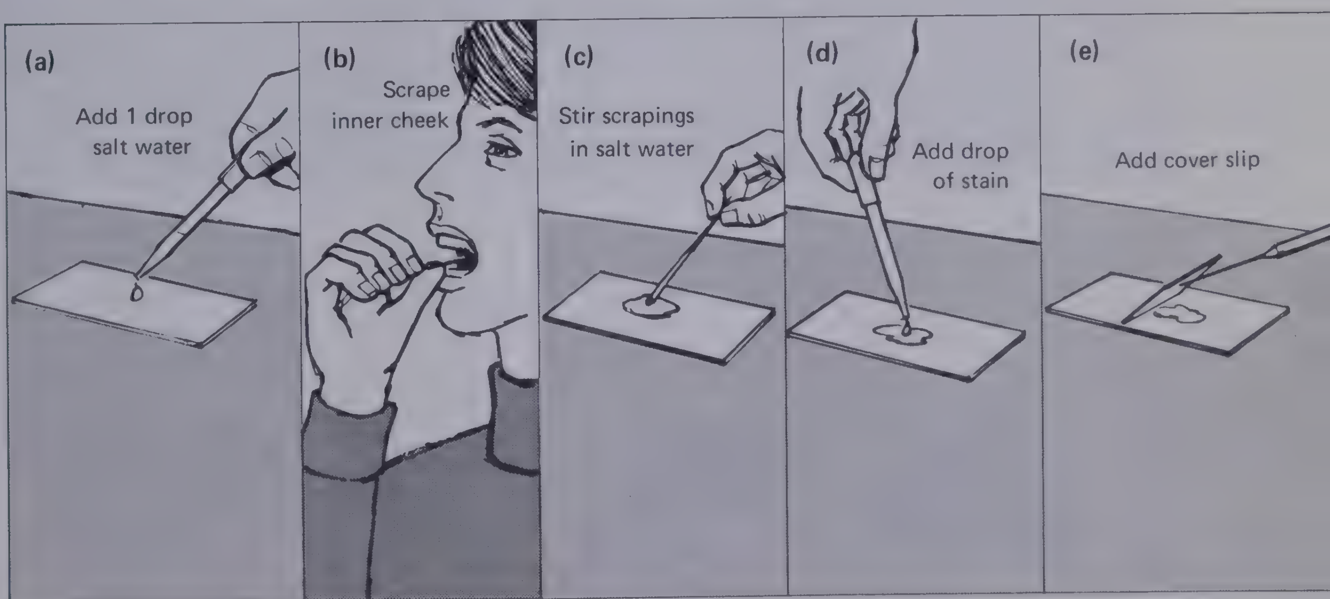
Look at the plant leaf you just drew. Notice that there is an outside covering, the *cell wall.* Then there are a number of things that make up the cytoplasm. The tiny, green dots are where the plant makes its own food. They are called *chloroplasts.* The large, dark body, the *nucleus,* is the control center. Label the three underlined parts in one of your bricklike structures.

2. What are each of these bricklike structures called?

C. WHAT ARE LITTLE BOYS AND GIRLS MADE OF?

So far you have looked at yeast and a plant leaf. What about an animal?

Place a drop of salt water in the center of a clean slide. The salty water is similar to human body fluid. With the blunt end of a toothpick, gently scrape the inner surface of your cheek and stir the scrapings in the salt water. Some of the structures may show up clearer if you add a drop of stain. Cover with a cover slip.



Draw what you see in space *c*.

Look at what you just drew. Note that the outer covering is so thin that the structure has no real shape. This covering is called the *cell membrane*. There is a dark area, the *nucleus*, inside the structure. Label the two underlined parts in one of your structures.

3. It is hard to describe the shape of the structures you observed. Each unit looks somewhat like a circle. What do you call each of these units?

D. WHAT ARE ALL LIVING THINGS MADE OF?

If they are available, examine at least two prepared slides. Make a drawing of each in spaces *d* and *e*. Label some of the parts you have just learned.

4. What structures do you find present in all of your drawings for this investigation?

5. There are many different kinds of living things. But living things have at least one structure in common. What is this structure?

6. You only saw three to five examples. However, what would you predict all living things are made of?

CONCEPT SUMMARY.

Investigation 6

Is There Order to Chaos?

You have studied that there are many different kinds of living things on the earth. You have also studied that despite the diversity of life, all living things have one thing in common. All living things are made of cells.

The Peaceable Kingdom, by Edward Hicks

(Collection of Edgar William and Bernice Chrysler Garbisch)

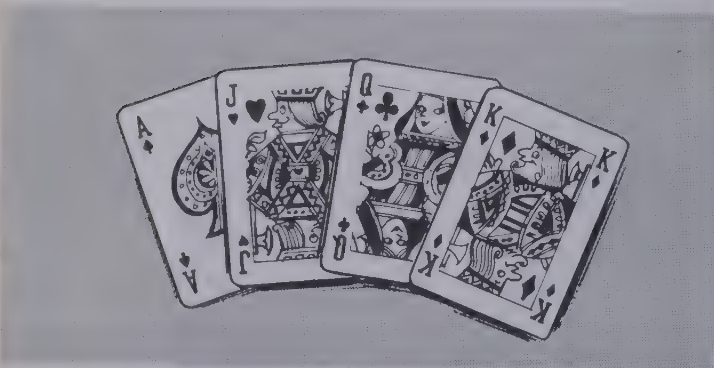
Do living things have anything else in common? For instance, the dog, the cat, the rat, and the porcupine have something in common. Do you know what it is?

A. FORGET ABOUT THE JOKER

Suppose you had a deck of cards in your hand. As you know, all 52 cards are different. Yet they are similar in certain ways.

How many different ways are 52 cards similar? How many different ways can you sort and group 52 cards?

Indicate the groups and the kinds of cards in each group in Table 1.



1. How did you group the 52 different cards?

B. CUTOUT, NOT CUTUP

You will be given an assortment of colored cutouts. You can see that all 20 cutouts are different. Yet are they similar in certain ways?

Is there any order to the collection? Try arranging them in groups on your table. After you finish, mix them all up and regroup them all in another way. Every time you regroup the cutouts, each of the 20 cutouts has to be in one group or another.

Indicate the groups and the kind of cutouts in each group in Table 2.

2. How did you group the 20 different cutouts?

C. CRAZY MIXED-UP ZOO

You will be given a collection of cards. Each card will have the picture of an animal, the name of the animal, and some information about the animal.

Sort these cards into stacks. All the cards in a stack must be related, and each stack must be related to the other stacks.

For instance, you are not to put:

Stack 1: all animals with wings

Stack 2: all animals that are gray in color

Stack 3: all animals that swim

Instead, you should decide on a closer basis for grouping. For instance, you may want to group all the animals by their *covering*. Then your stacks must contain:

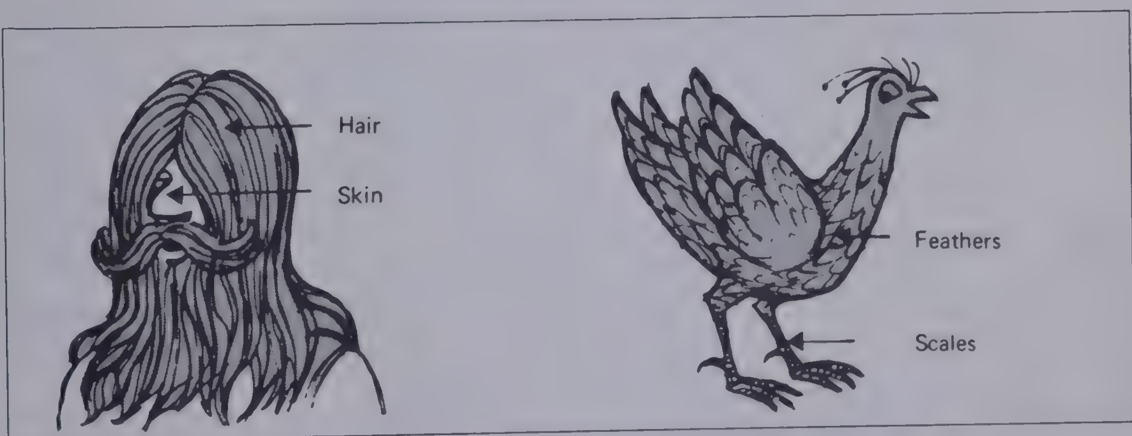
Stack 1: all animals with feathers

Stack 2: all animals with hair

Stack 3: all animals with scales

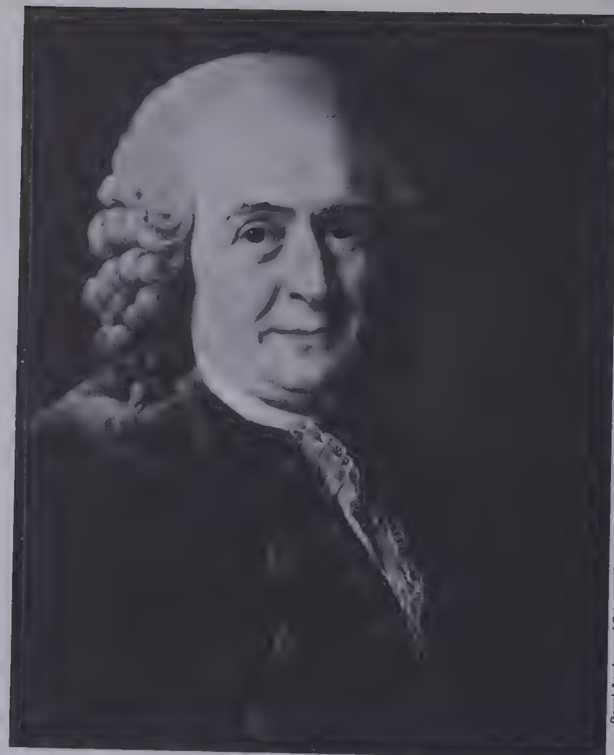
Stack 4: all animals with skin

There are many different ways you can group the animals. How many different ways can you find?



Record your data in Table 3.

3. How did you group your collection of different animal cards?



Carolus Linnaeus

In 1758, a Swedish scientist, Linnaeus, did something very similar to what you have been doing. You have been finding ways of grouping playing cards, cutouts, and animal cards. Linnaeus organized a system for grouping all the living things on earth. His system has since been improved. How living things can be grouped will be the subject of Investigation 7. But for now, complete the following sentence in your data sheet.

4. Despite the great diversity of life, living things can be ___?___

CONCEPT SUMMARY.

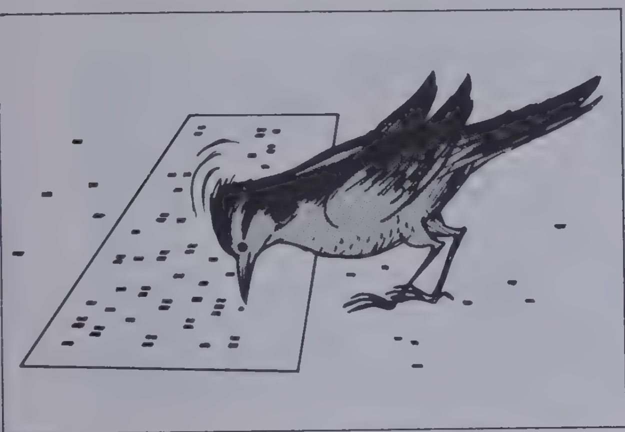
Investigation 7

Punch Card a Yellow-Bellied Sapsucker?

From the previous investigations, you have discovered that:

a. There is a great diversity of life on this earth.

b. The microscope can help us to see some living things that are not normally visible.



c. All living things are made up of one or more cells.

d. All living things can be arranged or classified into related groups.

In the last investigation, you noted that there are different ways of arranging playing cards into groups. You also found that the 20 cutouts could be grouped in different ways. And finally, you discovered that the animal cards could be classified in different ways, too.

* Of the many ways in which you classified ~~the animal~~ cards, might there be one way that is preferred by scientists?

A. IS THERE A WEBSTER IN SCIENCE?

You are all familiar with dictionaries. The dictionary uses one method of classifying words. The words are classified in alphabetical order.

tame

tame (tām), *adj.*, **tam er. tam est,** *v.*, **tamed, tam ing.** —*adj.* **1.** taken from the wild state and made obedient: *a tame bear.* **2.** without fear; gentle: *The squirrels are very tame.* **3.** without spirit; dull: *a tame story.* —*v.* **1.** make tame; break in. **2.** become tame. **3.** deprive of courage; tone down; subdue. [OE *tam*] —**tame′a ble, tam′a ble,** *adj.* —**tame′ly,** *adv.* —**tame′ness,** *n.* —**tam′er,** *n.* —**Syn.** *adj.* **1.** domesticated, domestic. **2.** docile. —*v.* **3.** curb, repress.

tame less (tām′lis), *adj.* that has never been tamed; that cannot be tamed.

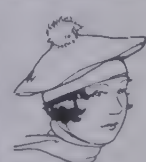
Tam er lane (tam′ər lān), *n.* 1333?-1405, Mongol conqueror of most of S and W Asia.

Tam il (tam′l), *n.* **1.** one of the Dravidian people of S India and Ceylon. **2.** their language. —*adj.* of or having to do with the Tamils or their language.

Tam ma ny (tam′ə nē), *n.* organization of politicians in the Democratic Party of New York City. —*adj.* of or having to do with this organization, its politics, methods, or members. [Am.E; from the name of a Delaware Indian chief of the 17th cent.]

Tammany Hall, **1.** Tammany. **2.** hall used as the headquarters of this organization.

tam-o'-shan ter (tam′ə shan′tər), *n.* a Scotch cap. Also, **tam.** [from the name of the hero in a poem by Burns]



Tam-o'-shanter

tamp (tamp), *v.* **1.** pack down: *tamp the earth about a newly planted tree.* **2.** in blasting, fill (the hole containing explosive) with dirt, etc. [? < *tampion*]

Tam pa (tam′pə), *n.* seaport in W Florida. 275,000.

tam per (tam′pər), *v.* **1.** meddle; meddle improperly: *Do not tamper with the lock.* **2. tamper with, a.** bribe; corrupt: *Crooked politicians had tampered with the jury.* **b.** change so as to damage or falsify. [ult. var. of *temper*] —**tam′per er,** *n.* —**Syn. 1.** See **meddle.**

Tam pi co (tam pē′kō), *n.* seaport in E Mexico. 115,000.

tam pi on (tam′pē ən), *n.* **1.** a wooden plug placed in the muzzle of a gun to keep out dampness and dust. **2.** plug for the top of an organ pipe. [< F *tampon*, ult. < *taper* plug < Gmc.]

Courtesy Thorndike-Barnhart Dictionary

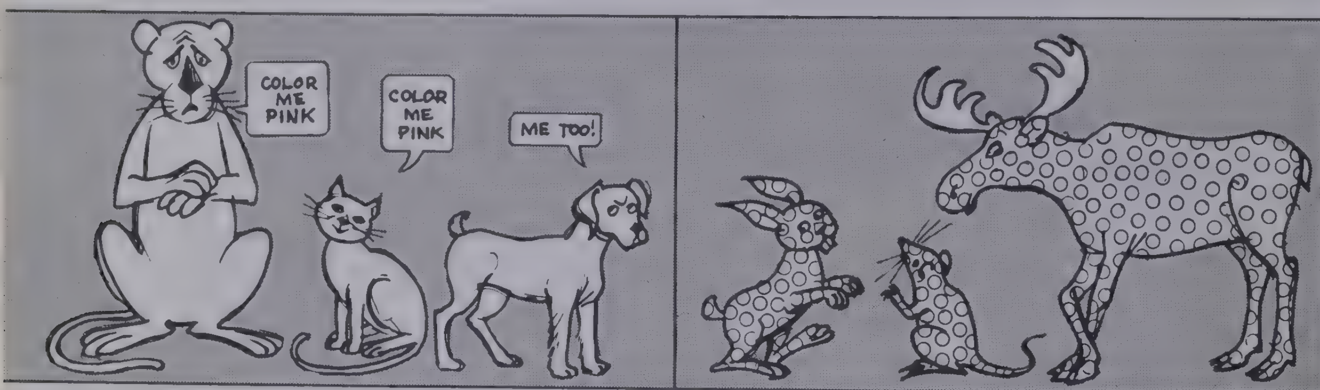
This is not the only way of classifying words. You could classify words by their length. All two-letter words could be grouped together, so could three-letter words, and so forth.

You could classify words by their origin, putting all words from Latin in one group, those from Spanish in another, and so forth. Can you think of other methods of classifying words? Although there are many different ways to classify words, the alphabetical method seems to be the most popular.

How about classifying living things?

1. Would location be a good system? Can we put all African animals in one group and all South American animals into another group? Explain.

How about pattern? Perhaps we can put all striped animals into one group and all polka-dotted animals into another group.



2. Do you think pattern is a good system? Explain.

The process of putting related objects, such as organisms, into similar groups is called *classification.* One system used today to classify organisms can be traced back to a set of books published in 1758 by the Swedish scientist, Linnaeus.

3. What do you predict is the preferred system used by scientists to classify living things?

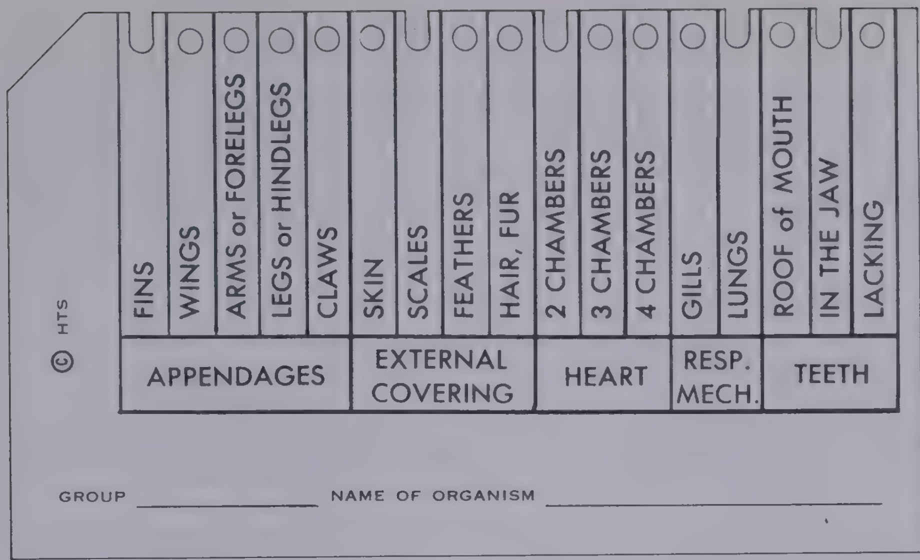
B. WHO'S RELATED TO WHOM?

Obtain the same collection of cards used in the last investigation. Each card will have a picture of an animal on it, the name of the animal, and some information about the animal.

Sort through the deck of cards and find the 15 cards that are different.

You will be given 15 data punch cards like the sample shown on top of next page.

Transfer the information from each of the animal cards to the data punch cards. The procedure is as follows:



a. Write the name of the organism on the punch card.

b. There are names of structures on the edge of the punch card. If the organism has any of the structures listed, cut a "V" in the hole above the structure. *Do not make a cut if the structure is absent.*

c. Repeat this procedure for the remaining 14 animals.

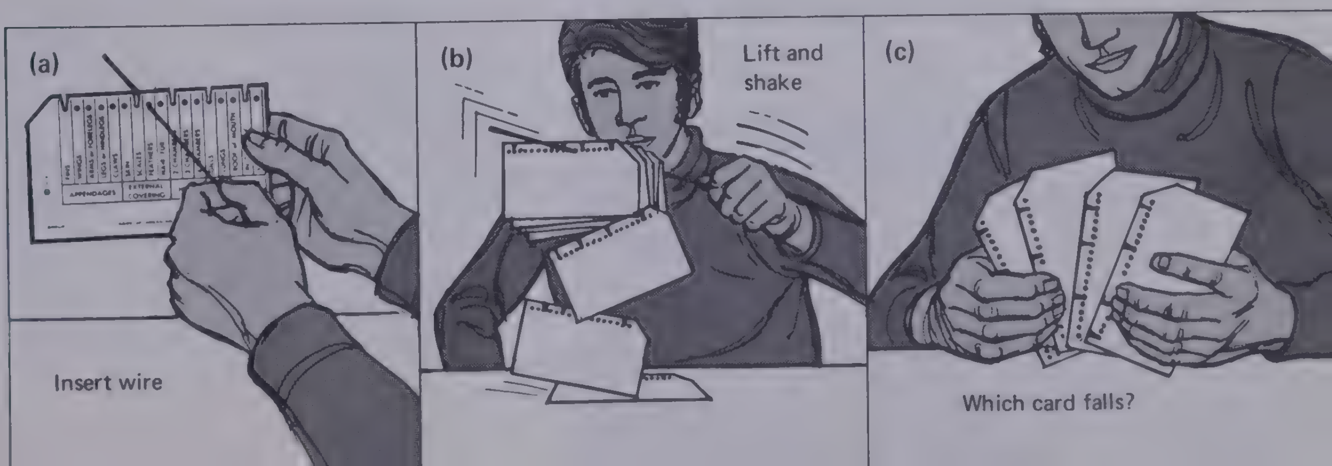
d. Leave the line after "Group" blank for now.

You now have 15 data punch cards, all punched in different ways. Is there any order to these differences? Let's see.

The sorting of the punch cards is very simple. Stack the cards in the same direction. Insert a straight wire or stick into the holes above the structure "fins," and lift. All the animals with that characteristic will drop from the stack. Pick up the cards that fell and repeat this process for the following structures: scales, 2-chambered heart, gills, and teeth along the jaw.

4. List all the animals sorted out.

5. These animals are all related. How are they related?



6. What do you think the group of animals sorted out in "4" is known as?

7. Sort out all the punch cards with the following characteristics: arms, legs, skin, 3-chambered heart, gills, lungs, and teeth in the roof of the mouth. List all the animals sorted out.

8. These animals are all related. How are they related?

9. What do you think the group of animals sorted out in "7" is known as?

10. Sort out all the punch cards with the following characteristics: arms, legs, claws, scales, 3-chambered heart, lungs, and teeth in the jaw. List all the animals sorted out.

11. These animals are all related. On what basis are we grouping the animals?

12. What do you think the group of animals sorted out in "10" is known as?

13. Sort out all the punch cards with the following characteristics: wings, feathers, scales, 4-chambered heart, lungs, and no teeth. List all the animals sorted out.

14. These animals are all related. What system are we using to classify the animals?

15. What do you think the group of animals sorted out in "13" is known as?

16. Sort out all the punch cards with the following characteristics: arms, legs, hair or fur, 4-chambered heart, lungs, and teeth in the jaw. List all the animals sorted out.

17. These animals are all related. On what basis are the animals being classified?

18. What do you think the group of animals sorted out in "16" is known as?

Now go back and write in the name of the group on each of the data punch cards.

If you wish, the cards with the animals pictured on them can be used for a card game. Your teacher will supply the directions for the game.

C. WE'RE ALL IN PLACE

As a result of this investigation, you have worked with one of the more popular ways in science to classify animals. This same system can be applied to plants.

19. How do you think Linnaeus arranged living things into related groups?

20. The world is full of different kinds of living things. Despite the great diversity of life, all living things can be classified into related groups based on their __?__

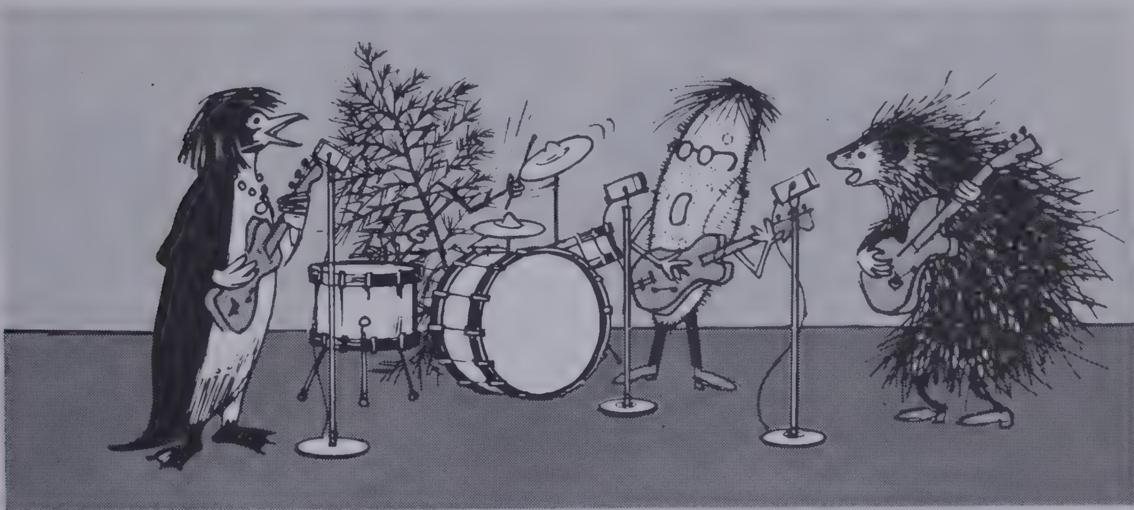
21. Classification is a way of bringing order to the diversity of living things. What is the basis for biological classification?

CONCEPT SUMMARY.

Investigation 8

You Can't See the Forest for the Rocks

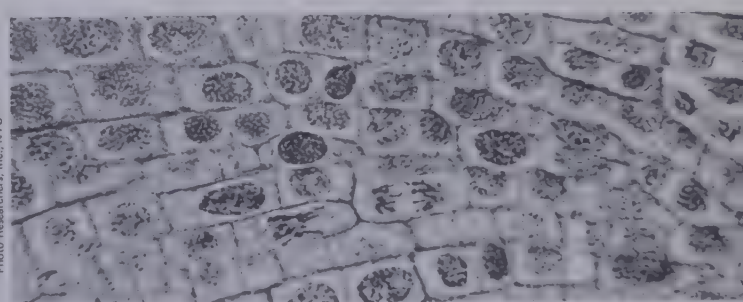
We live in a world that is full of many, many different kinds of living things. There are people—and penguins—and porcupines—and pine trees—and paramecia.



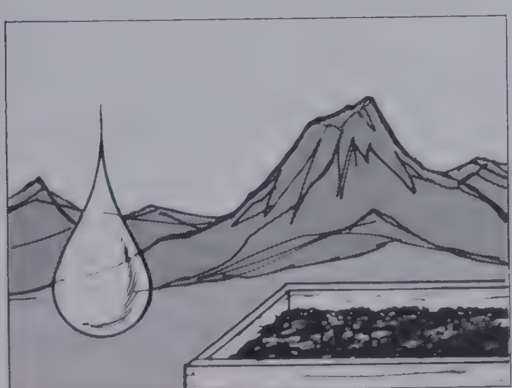
We find organisms living in a drop of water—in an inch of soil—and on mountain tops.

Even though there are many different kinds of living things, you have probably discovered that: All living things are composed of cells. AND All living things can be classified into related groups.

Photo Researchers, Inc., NYC



Onion Root Tip Cells



A. W. Ambler from National Audubon Society

These statements lead us to some very important questions. How did the different kinds of living things come to be? How did the different kinds of living things come to be separated into related groups?

A. A DINOSAUR IN MY TANK?

Millions of years ago, there were animals called dinosaurs that roamed the earth. Yet these dinosaurs are not known to be alive today. What proof do we have that dinosaurs existed?

©The Field Museum and Charles R. Knight

Let's take another example. The giraffe did not always have a long neck and long legs. In fact, at one time the giraffe looked like today's horse. But what evidence do we have to prove it?

You now have some background for our problem. As you have learned, a scientist often makes a prediction to help find the possible answer of a problem. This is what you are to do.

1. What do you think has been happening to living things over millions and millions of years?

You have just made your prediction. But it is just an educated guess. Your guess must now be tested. A scientist must produce data or evidence that will either support or reject the prediction.

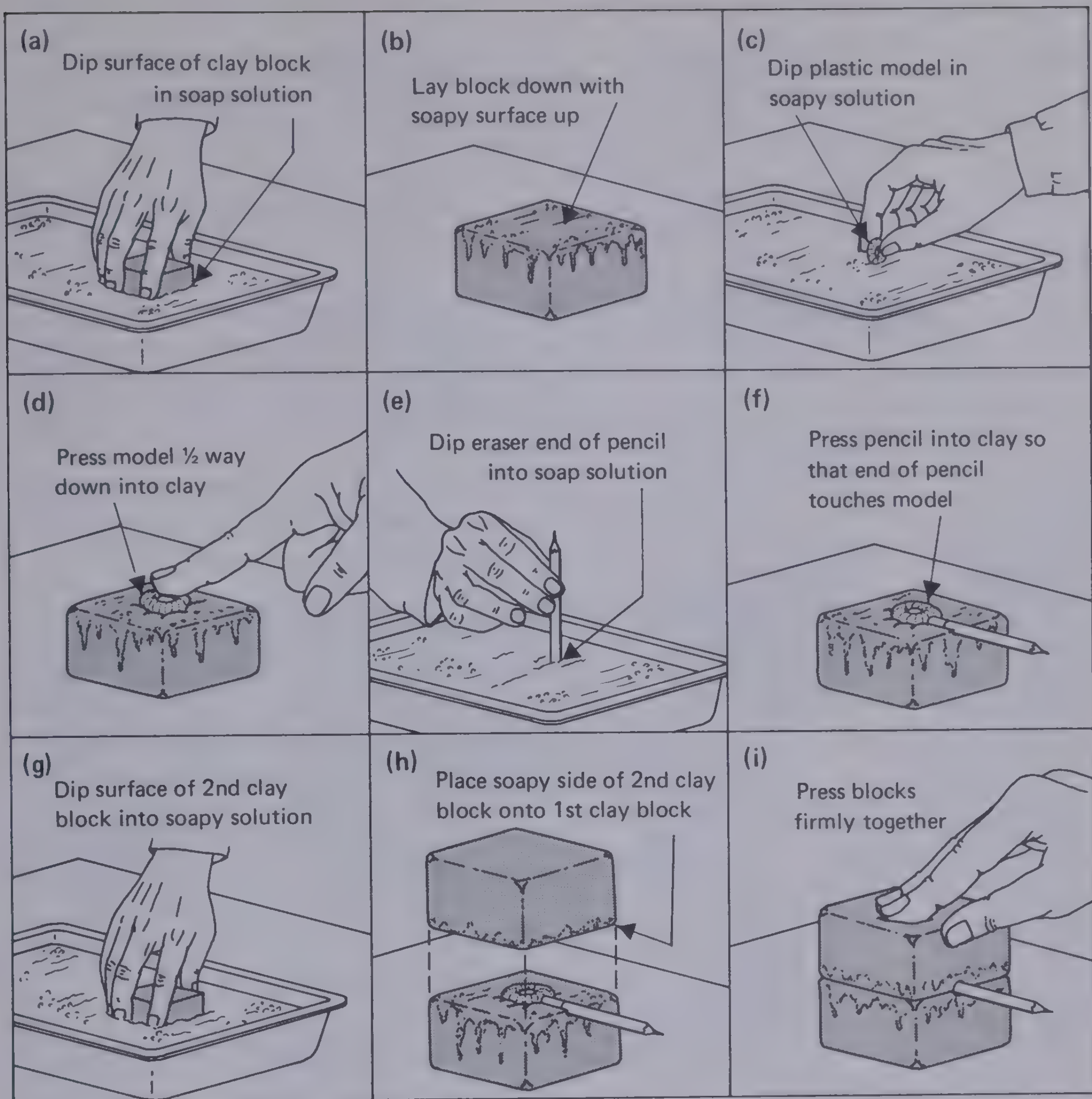
2. What evidence do you think scientists have that will support the prediction you made in "1"?

B. IT'S PRESERVED IN ROCK

Obtain two blocks of modeling clay. Take one block of clay and dip one of its large surfaces in a soap solution. Lay this block on the table with the soapy surface facing up.

Obtain a plastic model of an animal from the teacher and dip it into the soap solution. Then press the model halfway down into the clay block. Imagine that you are looking at an animal that died many millions of years ago. Now dip the end of a pencil into the soap solution and press it into the clay block as pictured.

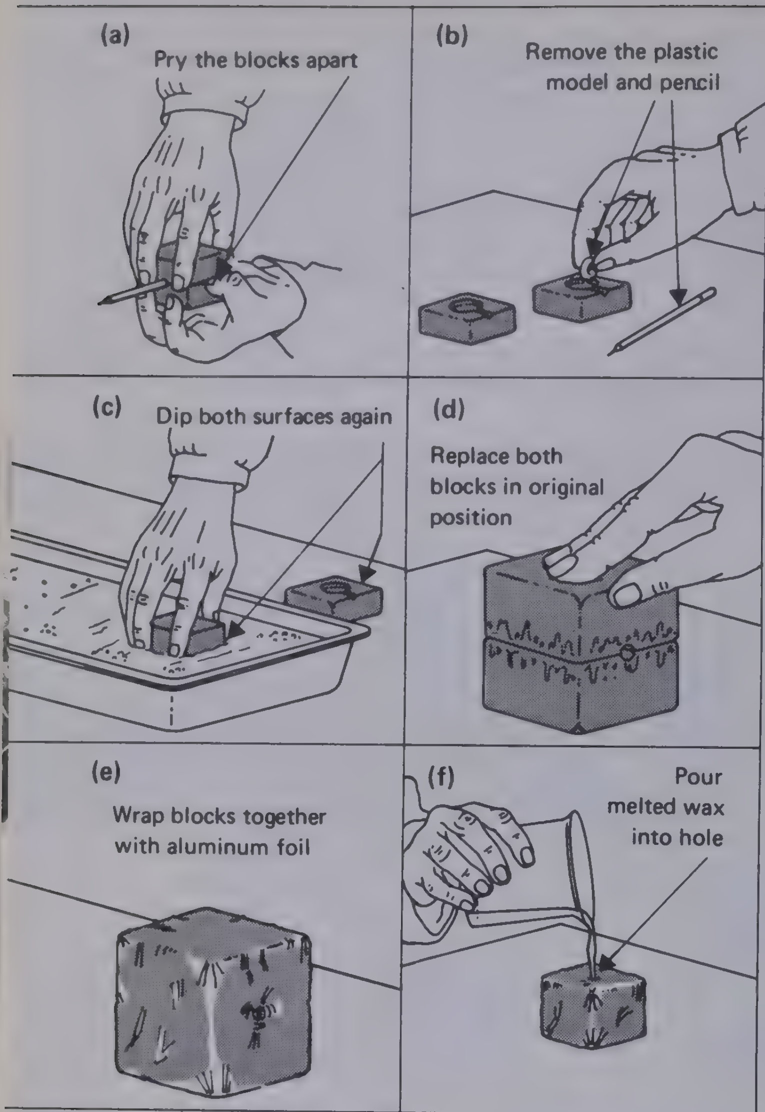
Dip one of the large surfaces on the other block of clay into the soap solution. Then press this block onto the first block firmly. This second block represents sediment that buried the dead animal.



Usually, most organisms that die are either eaten or destroyed by decay. But sometimes burial in sediment preserves the animal for millions of years from decay and the attack of scavengers. There are scientists who look for and study these preserved animals.

Carefully separate the two halves. This action would never happen so fast in nature. Normally, the earth would slowly wear away or the scientist would carefully pick away at the sediment to find this hidden treasure. What you see inside your clay blocks represents an animal that has been preserved for millions of years.

©The Field Museum of Natural History



3. What do you call an organism or a part of an organism that has been preserved for millions of years?

Not all organisms are preserved in this way, however.

Remove the plastic model and the pencil. Dip the same two surfaces in the soap again. Now place the two blocks of clay together in its original position.

Using the melted wax which has been prepared, pour the wax into the hole at one end of the blocks. Set it aside to dry.

In pouring wax into the clay, you are replacing the original mold of the organism with another material. In nature, this substitution takes place as water and chemicals drip through tiny holes in the sediment.

After twenty minutes, carefully pry apart the two clay blocks to reveal the wax *cast* or model.

4. What does the cast represent?

This is only one way in which prehistoric organisms can be preserved.

C. THE RECORD OF LIFE

5. What do you call an organism, or a part of an organism, that has been preserved through time?

6. How does examining prehistoric remains help us to understand about the past?

7. What is one form of evidence that scientists have been able to "dig up" to support the prediction you made in question 1?

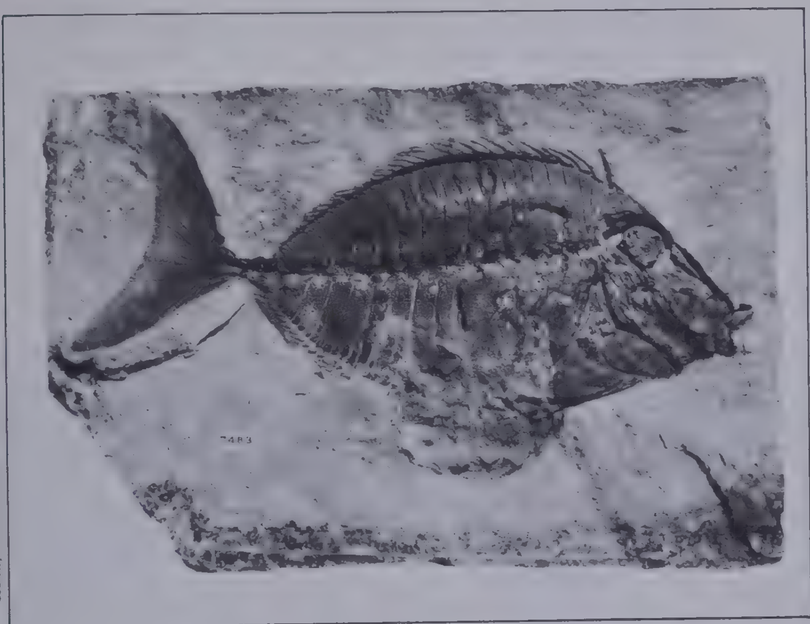
CONCEPT SUMMARY.

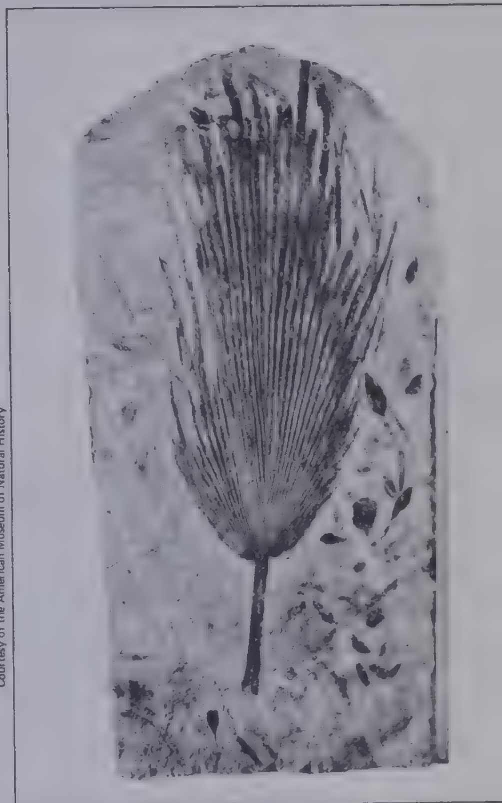
Investigation 9

A Horse, Is a Horse, Is a Horse?

Fossils represent the visible remains of prehistoric organisms. Fossils give us proof that life existed in a different form at one time.

Fish Fossil



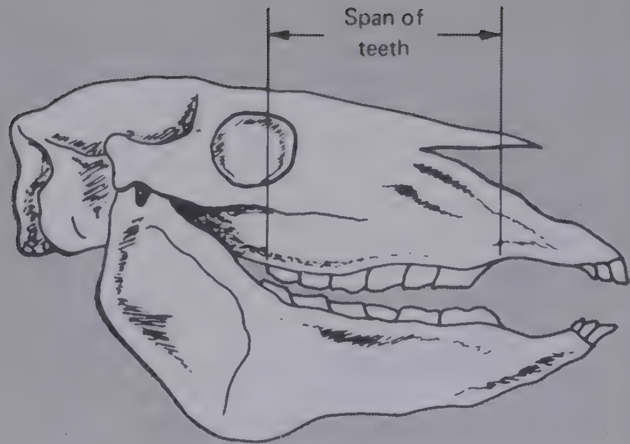


Plant Fossil

You predicted in the last investigation that living things have changed through time. We call change through time *evolution*. One evidence of evolution is given by fossils.

You examined some samples of fossils in the last investigation. However, a few fossils cannot give you a complete story. You still do not have any proof of change. You only have evidence that life existed a long time ago.

How can fossils show that living things have changed their forms through time?



A. LOOK MA, NO CAVITIES

Fossil evidence is rather plentiful in the case of the horse. There are fossils of horses or horselike animals as far back as 70 million years ago. The span of the cheek teeth has been measured in many of these fossil remains.

The data for each group and its time of existence are shown in the table below:

Group	Time of Existence Millions of Years Ago	Span of Cheek Teeth in cm.
Eohippus	70	4.3
Orohippus	50	4.3
Epihippus	45	4.7
Mesohippus	35	7.3
Miohippus	30	8.3
Parahippus	30	10.0
Merychippus	15	12.5
Hypohippus	15	14.2
Pliohippus	7	15.6
Calippus	6	13.3
Equus	1	18.8

On Graph 1 in your data sheet, plot the relationship between time of existence and span of teeth. Don't forget to include: properly labeled coordinates, legend showing each group of horse, and units.

1. What does the graph tell you about what has happened to the span of horses' teeth through history?

2. What prediction would you offer to explain why the span of cheek teeth changed?

B. THEY'RE OFF AND RUNNING

Look at the diagram of the front and back hooves (toes) of these horses.

3. Which is the oldest horse and how many hooves did it have?

4. How many hooves does the modern-day horse have?

5. What happened to the number and size of the hooves through time?

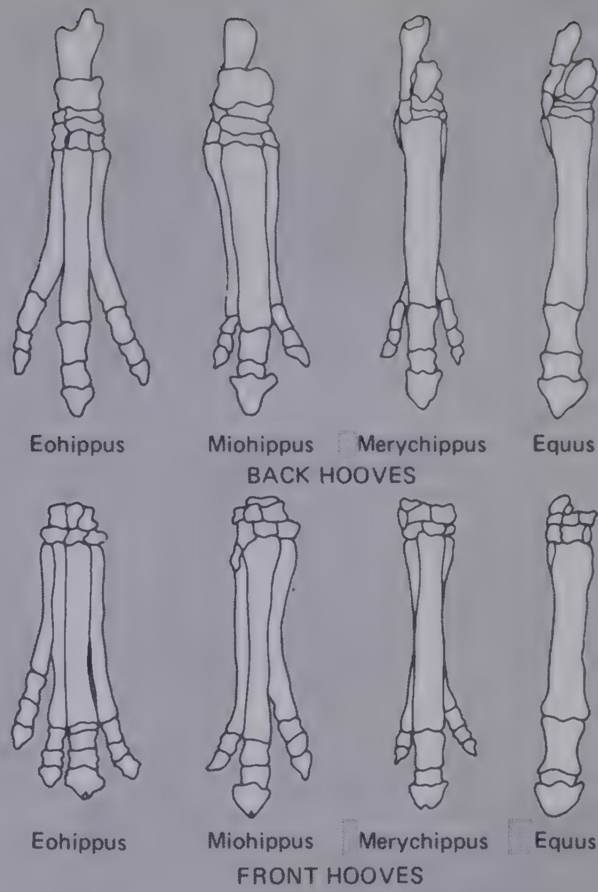
6. What do you predict is the cause of the change in the hooves?

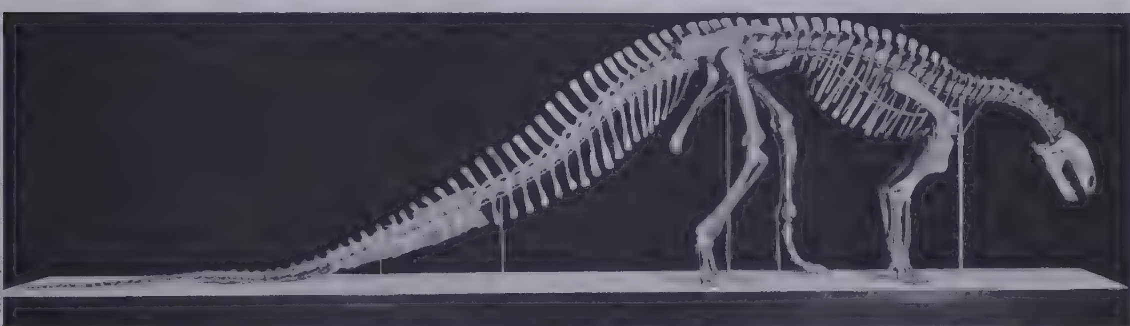
The key questions are "1" and "5." You have evidence to help you answer these questions. The answer should be the same for both questions.

You have no evidence to answer questions "2" and "6." You can only offer an explanation. You will have an opportunity to check your explanation in Investigation 11.

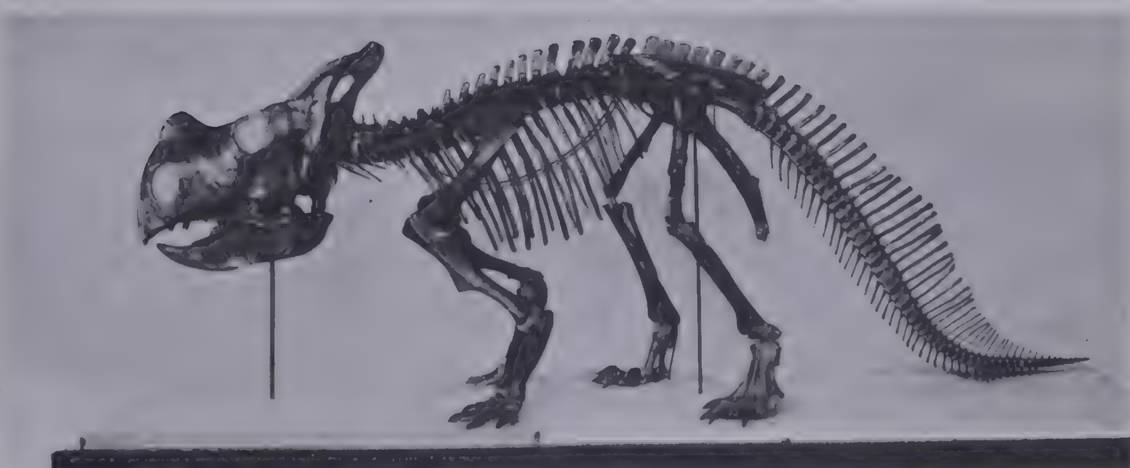
C. NO ORDINARY SET OF BONES

Some of you may have visited a museum where sets of bones have been put together.





Courtesy of the American Museum of Natural History



Courtesy of the American Museum of Natural History

These sets of bones may represent a kind of animal that lived at different times in history. For instance, suppose that fossil bone sets of a giraffe were collected and put together. Using a method to find the age of the bones, scientists could discover that each set of bones came from a different time in history. They might also note that each set of bones is slightly different.

7. By examining sets of fossils from different times in history, what do you think scientists might learn about living things?

CONCEPT SUMMARY.

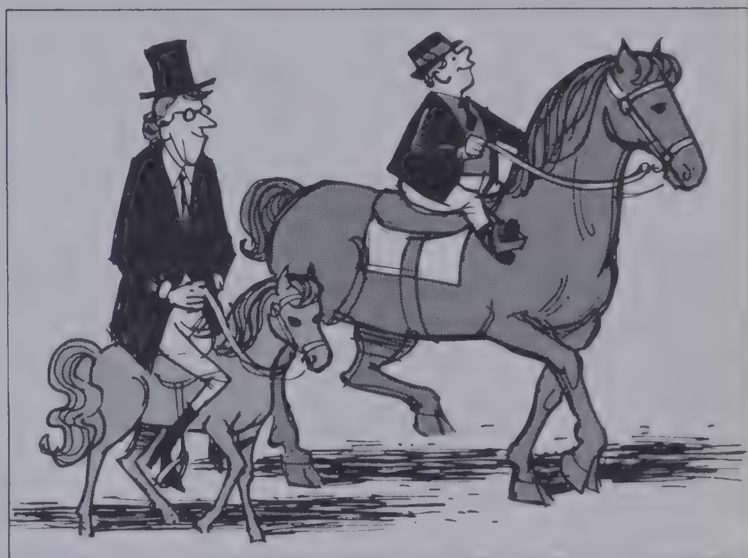
Investigation 10

Variety Is the Spice of Life

You have studied that there is a great diversity of life on this earth. One reason for this great diversity is because living things have changed through time. We call this evolution. The process of evolution has resulted in the many different kinds of living things on this earth.

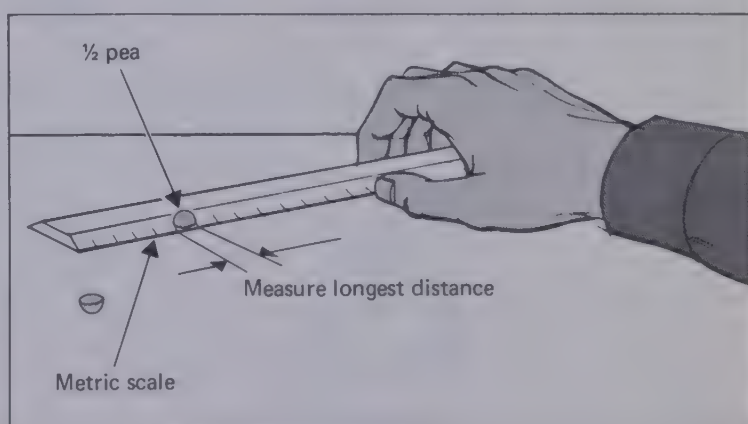
However, have all horses changed in the same way? Have all people evolved in the same way? To put it another way, are all horses the same and are all people the same?

A. THEY COME IN PODS, NOT BOXES OR CANS



You will be given a small handful of soaked pea seeds. Using your fingernail, split each pea in half. Place one-half of each pea seed in a Petri dish and the other half in the cover of the dish. Use only the split peas in the Petri dish. The split peas in the cover will be collected.

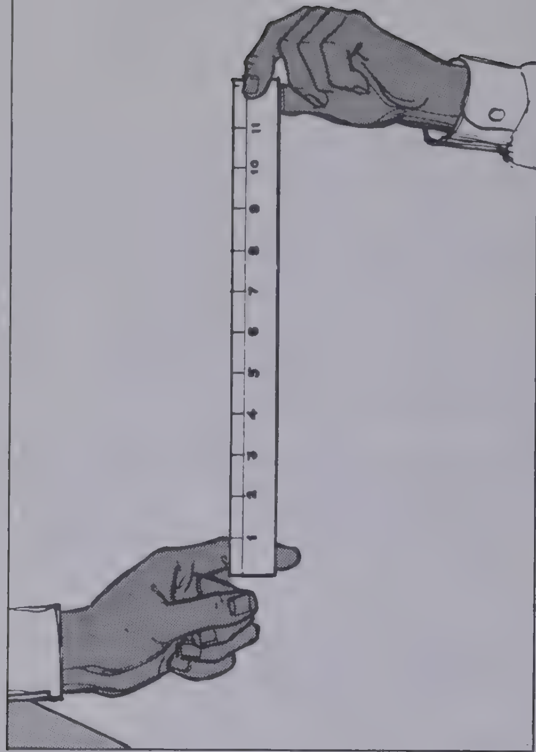
Place the flat surface of each half pea on the ruler and measure its longest dimension to the nearest millimeter. Your teacher will help the class to determine the range of pea diameters from smallest to largest. Fill in line 1 of Table 1 with this information. Then record your count and the total class count.



Prepare a graph of the class results in Graph 1.

B. YOU HAVE TO RAKE THEM ALL FALL

You will be given a small pile of leaves. Measure the length of each leaf. Your teacher will help the class to determine the range of leaf lengths from smallest to largest. Fill in line 1 of Table 2 with



this information. Then record your count and the total class count.

Prepare a graph of the class results in Graph 2.

C. HOW FAST ARE YOU?

You are to measure the reaction distance of your partner. Have your partner place his arm on a table and extend his hand over the edge of the table. Hold a ruler at the end marked "12" and hang the ruler so that the other end is between your partner's thumb and first finger. Your partner is not to hold the ruler.

When you release the ruler (without warning), your partner is to catch the ruler with his thumb and first finger.

Note where your partner catches the ruler. If he catches the ruler between two numbers, record the lower of the two numbers.

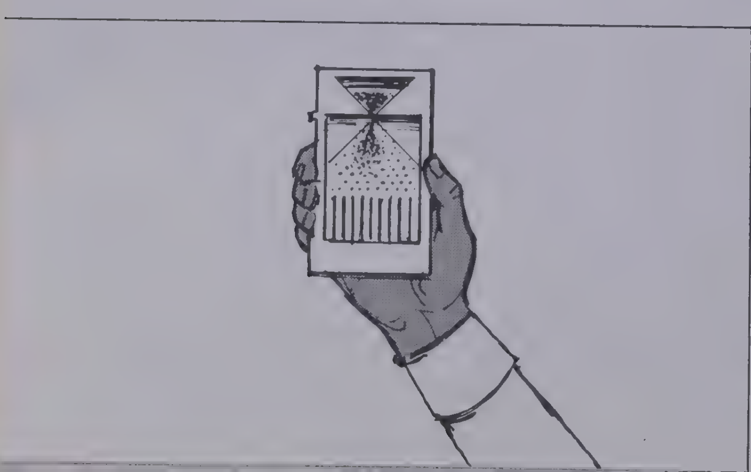
Repeat this 5 to 10 times. Everyone should do it the same number of times. Use a tally mark to record each count on line 2 in Table 3. Change places and have your lab partner repeat this test on you. Then record the total class count.

Prepare a graph of the total class count in Graph 3.

D. DON'T GRADE ON THE CURVE

Obtain a probability game from your teacher. The instructions for operating the device are printed on the back.

Record the number of balls that fall into each column in Table 4.



Prepare a graph of your results in Graph 4.

E. ARE THEY ALL ALIKE?

1. What do you notice about the general shape of all four graphs?

2. What shape do all four graphs resemble?

3. Does a graph of this shape mean that every individual is the same? Explain.

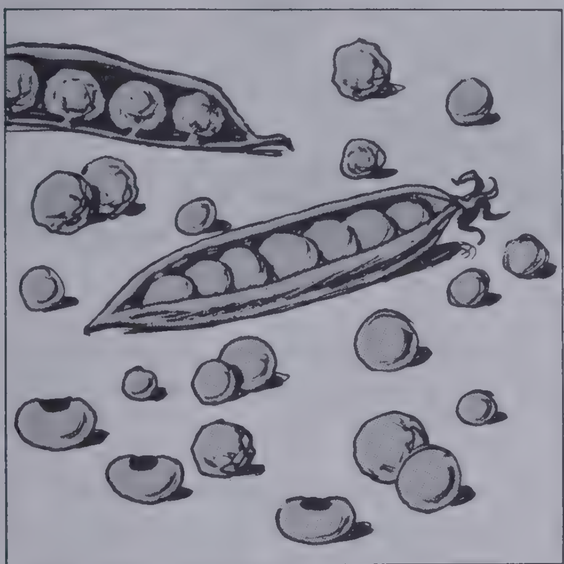
4. What does a graph of this shape tell you about a group of peas?

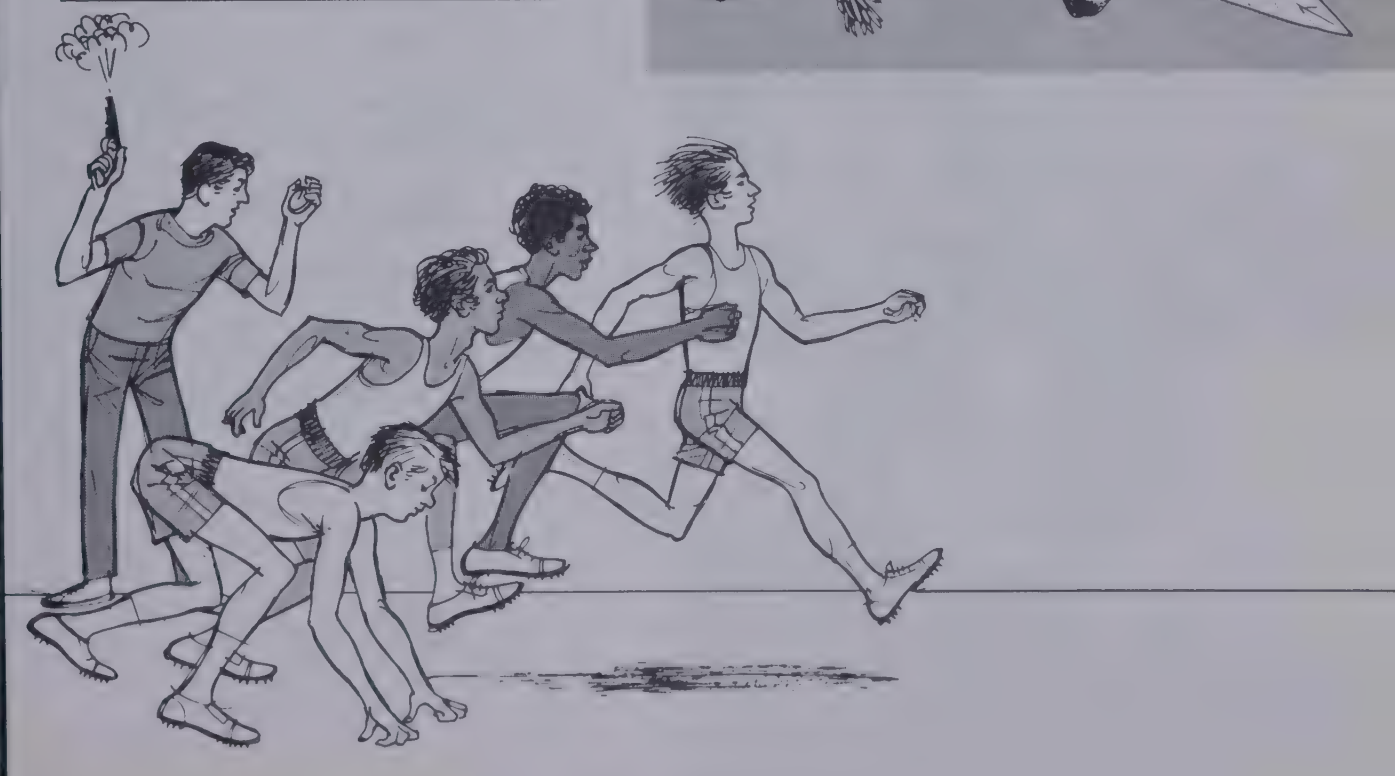
5. What does a graph of this shape tell you about a group of leaves?

6. What does a graph of this shape tell you about the reaction time of people?

7. If you had weighed beans, what kind of a graph do you think you would have gotten?

8. If you had measured grasshopper legs, what kind of a graph do you think you would have gotten?





David S. Strickler from Monkmeyer Press Photo Service

Bruce Roberts from Rapho-Guillumette

Sybil Shackman from Monkmeyer Press Photo Service

9. If you had measured the necks of giraffes, what kind of a graph do you think you would have gotten?

10. If you had counted the different colors or shades of an animal, like a skunk or a moth, what kind of a graph do you think you would have gotten?

11. Are all individuals within one kind of life the same? Explain.

12. What color skin do Negroids have?

13. What color skin do Caucasoids have?

14. What color skin do Mongoloids have?

15. But what are all Negroids, Caucasoids, and Mongoloids?

16. Therefore, we can say that there is a great diversity of life. But what can we say about individuals within each kind of life?

CONCEPT SUMMARY.

Investigation 11

Survival of the Fattest

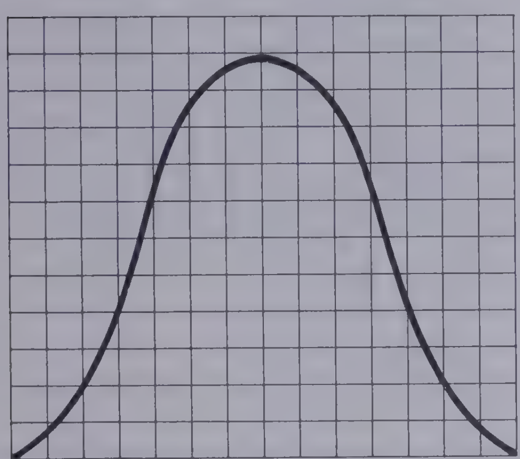
Here is a summary of the key concepts you have studied in this Idea:

a. There are many different kinds of living things. (Diversity)

b. The different kinds of living things can be arranged in related groups. (Classification)

c. Fossils are one form of evidence that living things have been changing through time. (Evolution)

d. Individuals differ within each kind of living thing. (Variation)



In the last investigation you discovered that individuals differ, but there was a pattern to the differences. For instance, you discovered that not all peas are the same size. Some are small and some are large, but most are medium in size. If graphed, the pattern would look like the bell-shaped curve.

Remember this pattern. Not all individuals of one kind of life are the same, but there is a pattern to the differences.

A. WHAT, MORE CUTOUTS?

You will be given a box. Please do not open it yet. Shake the contents well.

Open the cover and immediately pick up five of the objects. Pick any five. Do not sort.

Record the five you picked on line 1 of Table 1. Record the total class count on the next line.

Sort the objects that are left in the box in their respective colors. Arrange the stacks in order from black to white. Then place each stack in single file from black to white.

1. What shape does the entire collection of stacks resemble?

2. What does this pattern tell you about the individuals that make up one kind of life?

3. Did the class pick out more dark objects or more light objects?

4. Why do you think the class picked the objects they did?

Place all of the objects in an envelope to be stored.

B. WHAT, EVEN MORE CUTOUTS?

You will be given another envelope of objects. Empty these into the box. Cover the box and shake the contents well.

Open the cover and immediately pick up any five of the objects. Do not sort.

Record the five you picked on line 1 of Table 2. Record the total class count on the next line.

Sort the objects that are left in the box in their respective sizes. Arrange the stacks in order from small to large. Then place each stack in single file from small to large.

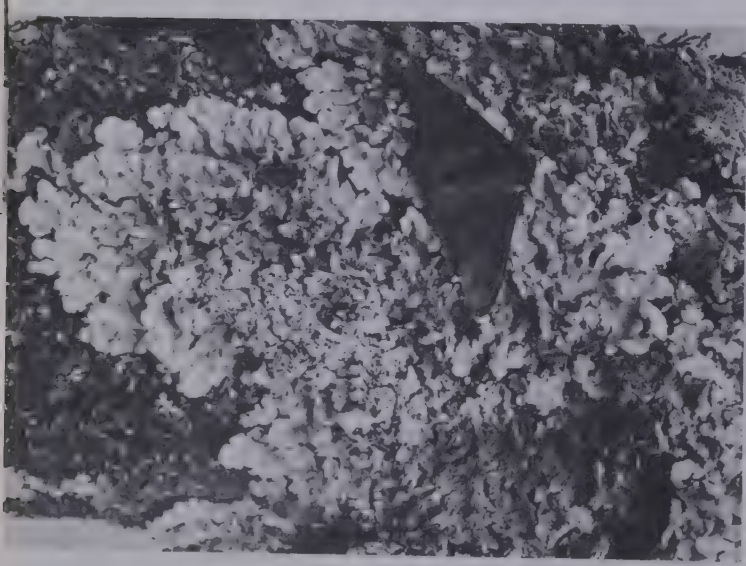
5. What shape does the entire collection of stacks resemble?

6. What does this pattern tell you about the individuals that make up one kind of life?

7. Did the class pick out more small objects or more large objects?

8. Why do you think the class picked the objects they did?

Place all of the objects in the envelope.



Dr. H. B. D. Kettlewell

C. THE MOTHS OF MANCHESTER FOREST

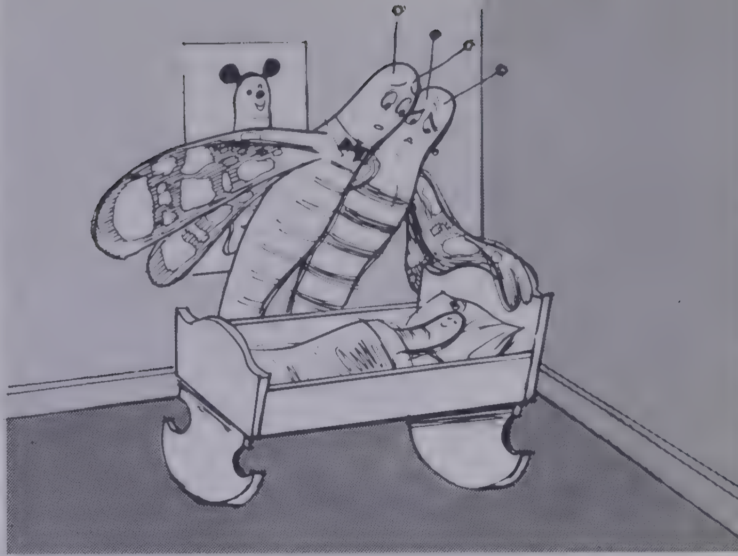
Imagine that a population of moths lived in a forest. The moths varied in color from light to dark.

9. Remember the pattern of differences. Can you predict the color of most of the moths?

Most of the trees in this forest had bark that was light in color. Some of the birds in the forest fed on the moths.

10. What color moths would be eaten by the birds more frequently? Explain why.

11. If the uneaten moths mated, what would be the color of many of their offspring?



Further imagine that after a number of years, the nearby city became more and more industrialized. Smoke poured out of the chimneys and settled on the tree trunks.

12. What happened to the color of the tree trunks as time progressed?

13. What color moth would now be eaten by the birds more frequently? Explain why.

14. If the uneaten moths mated, what would be the color of many of their offspring?

15. As the years continued, the trees became darker and darker. If the surviving moths of each generation were to continue to mate, what do you think would happen in time to the color of most of the moth population?

16. You might say the moths evolved from one color to another. What caused the change to take place?

Dr. H. B. D. Kettlewell

Courtesy of the American Museum of Natural History

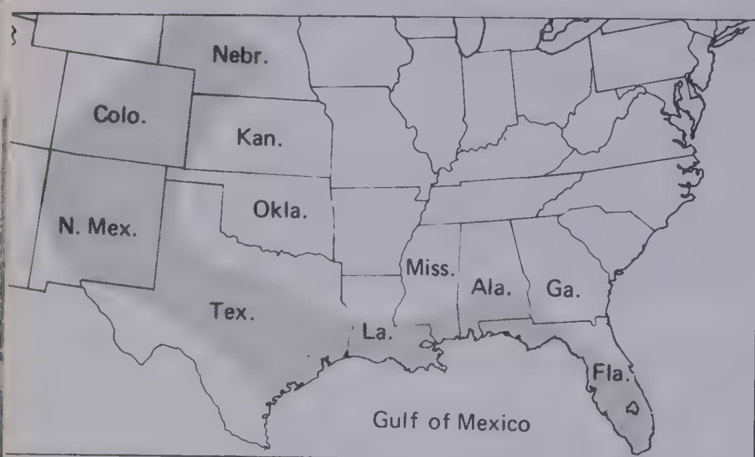
D. AND NOW, DOWN TO TRACKSIDE

In Investigation 9, you discovered that the horse slowly changed through time. There was fossil evidence to prove that the span of the cheek teeth increased and the number of toes decreased.

You were also asked to predict why the changes took place. Now let's look at some evidence.

Eohippus, who lived 70 million years ago, was a small animal. He was no larger than a good-sized dog. His teeth were small. He had short legs with four toes on each front leg and three toes on each hind leg.

He roamed the area we now call Nebraska. The Gulf of Mexico extended up into Nebraska at that time. All of Nebraska was covered by a lush forest.

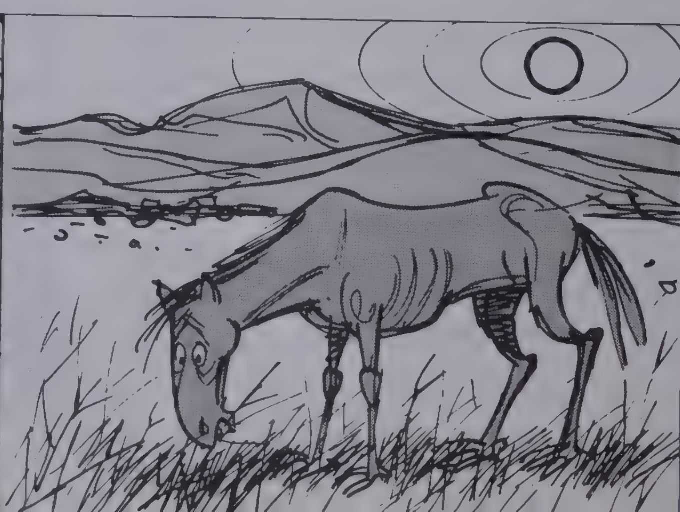


Eohippus lived in this lush forest. The heavy foliage provided him with cover for protection and food to eat. However, as millions of years passed, the Gulf of Mexico moved farther and farther south of Nebraska. The forest changed. It began to thin out because the air was no longer as humid. *Eohippus* and his ancestors lost their forest protection.

17. As the forest thinned out, which horses would probably get caught by a predator?

18. Which horses had a better chance of escaping from a predator?

19. What body structure gave some of the horses the ability to get away from their predators?



20. Of the horses that survived in this changing environment, many became the parents of the next generation. In terms of escaping from predators, what type of offspring might these horses have more frequently?

As you learned in Investigation 9, the horse has evolved from an animal with many toes to one with only one toe or hoof on each leg. In addition, the legs of horses have gotten longer.

21. Using your answer to question 20, explain why the number of toes and the length of the legs changed through time.

In addition to losing his forest protection, *Eohippus* found a change in his diet. The supply of soft forest-type leaves was slowly replaced by harder grasses which grew where the beach used to be.

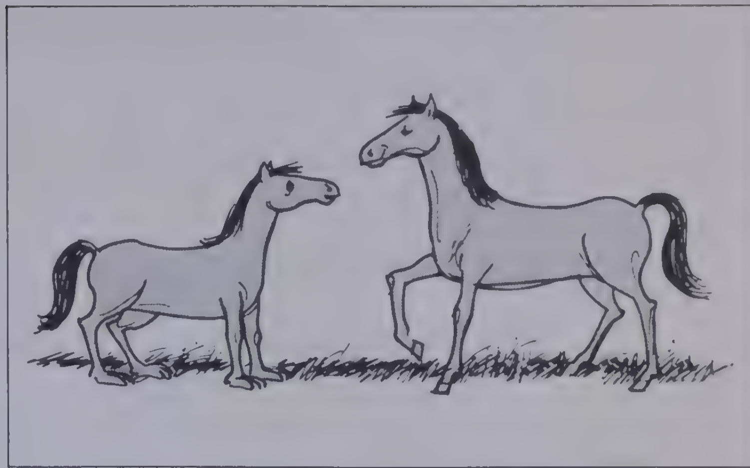
22. As the type of food changed, which horses had a lesser chance of surviving?

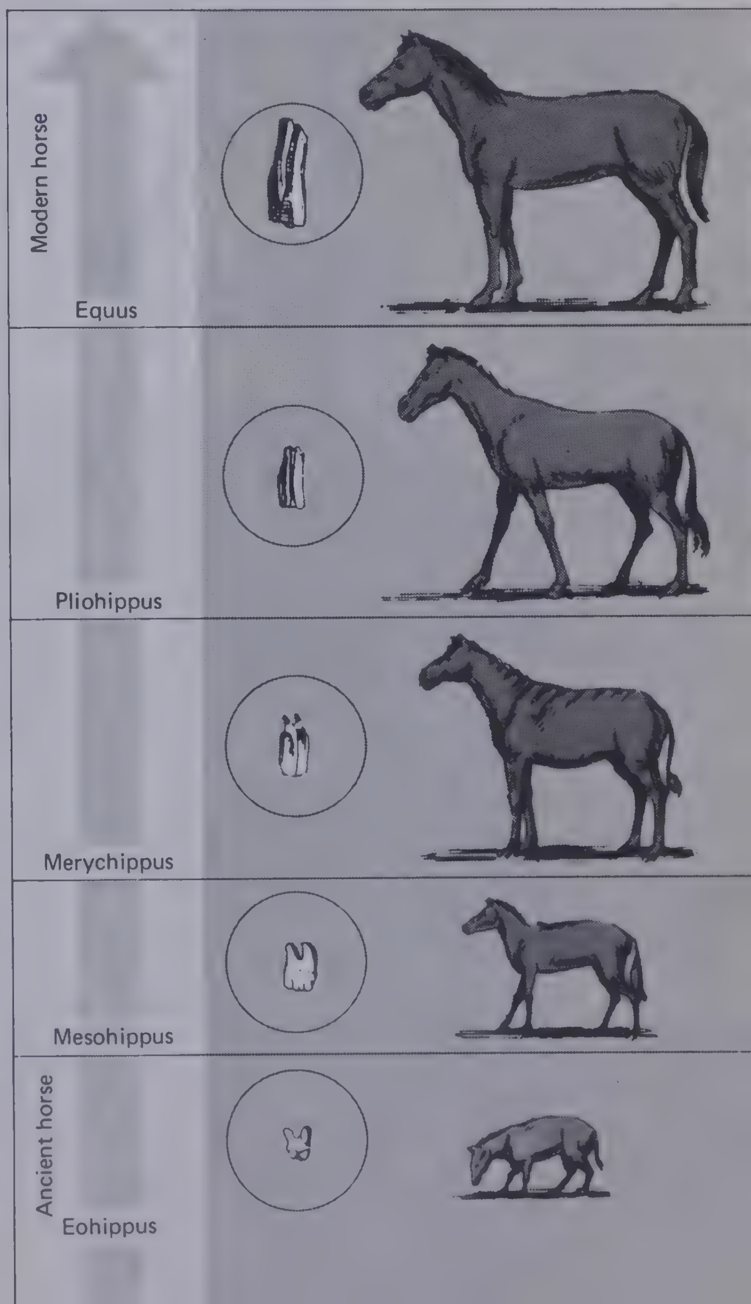
23. Which horses had a better chance of surviving on the slowly changing diet?

24. What body structure gave some of the horses the ability to survive on the harder grasses?

25. In terms of the size of teeth, what type of offspring might the surviving horses tend to have more frequently?

As you learned in Investigation 9, the horse has evolved from an animal with a smaller span of teeth to one with a larger span of teeth. The teeth themselves changed from being long and thin to short, large, and stubby. As the teeth size increased, the span of cheek teeth also increased.



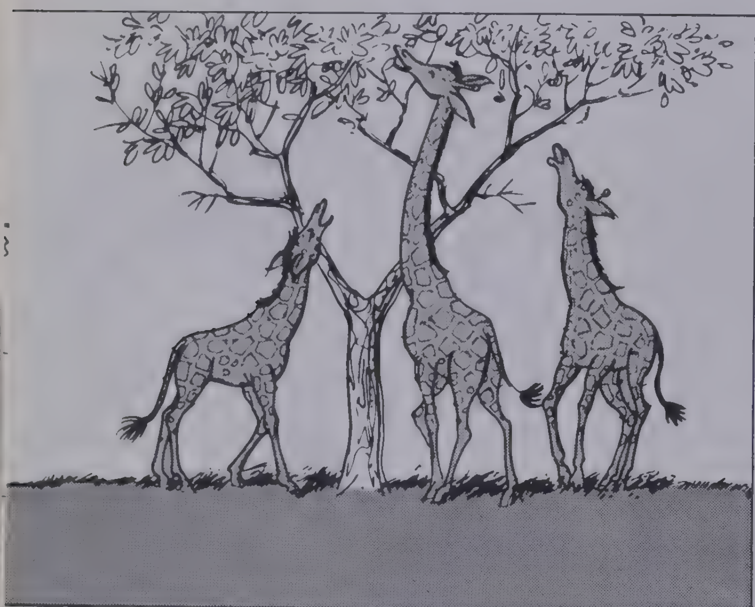


To help you answer the next question, think about your own teeth. The front are long and thin. What are they good for? Your back teeth are shorter, larger, and more stubby. What are they good for?

26. Now explain why the size of the teeth and the span of the cheek teeth changed in the horse through time.

E. WHO SURVIVES?

To summarize, you have learned that individuals differ. Because of these differences, some will have a better chance of surviving.



27. What differences will give some individuals a better chance of survival?

It should be pointed out that there may be many differences that help an organism survive. A more favorable structure is not the only reason.

Those organisms that survive live to give birth to young that are similar to the parents. This idea was observed, studied, and proposed by Charles Darwin just over a hundred years ago. He called it the *Theory of Natural Selection.* Some people also call it the *survival of the fittest.*

28. According to Darwin, what was nature selecting?

The drawing above shows a giraffe with a long neck munching on the leaves of a tree, while giraffes with shorter necks strain to reach the leaves. The giraffe did not get its long neck by stretching its neck to reach higher leaves.

29. Using Darwin's Theory, how would you explain how the giraffe got its long neck?

30. Using Darwin's Theory, explain why we have so many different kinds of living things on this earth.

31. In summary, according to Darwin, what kind of an individual survives?

CONCEPT SUMMARY.

Investigation 12

People Are Beautiful

In the last few investigations, you have learned about a very big idea in science, the idea of evolution. Evolution is the process of slow change in organisms over millions of years. Evolution can help us explain why there is a diversity of organisms on this earth.

A man named Darwin proposed an explanation for evolution. He said that in every group of organisms, there would be differences in their characteristics. These differences might give some of the organisms a more favorable advantage in a given environment.

The organisms which had more favorable characteristics had a better chance of surviving. They, in turn, would give birth to offspring that were like the parents. If this were to continue for many generations, a gradual change or *evolution* would take place.

Darwin called his explanation *natural selection.* Nature tends to select the fittest to survive and reproduce more of their own kind. You used this idea in the last investigation to explain the long neck of the giraffe and each long leg and hoof of the horse.

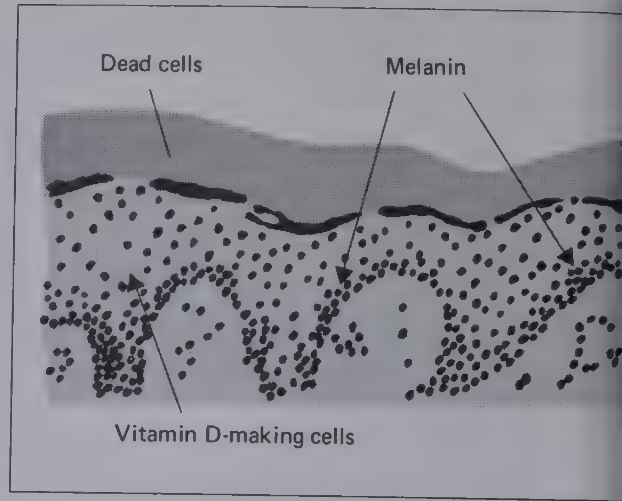
Can Darwin's explanation be used to explain skin coloration?

United Nations

A. DO CHINESE GET SUNTANNED?

Your skin has several layers. There is a tough, outside layer of dead cells.

The inside layers contain living cells, some of which make a brown or black substance called *melanin.* A person's skin color depends on the amount of melanin present. When you are in the sun, you are actually increasing the amount of melanin in your skin. Melanin also blocks out some of the rays of the sun. The greater the amount of melanin in a person's skin, the greater the blocking of the sun's rays.



Human Skin

Sunlight also exposes your skin to *ultraviolet light,* a kind of light you cannot see. It has been found that the *skin can make vitamin D if ultraviolet light is shined on it.* Vitamin D in important because it prevents a bone disease called *rickets.*

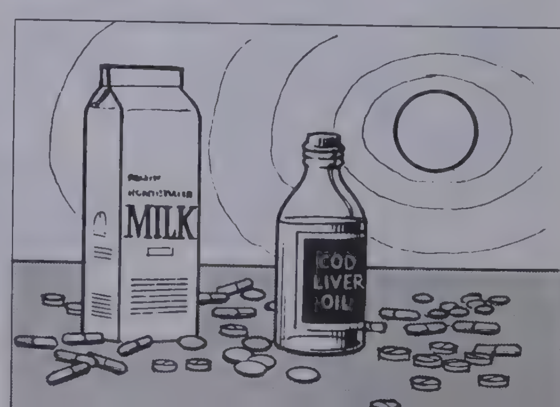
UNICEF

To prevent children from growing up with softened bones, crooked legs, and a twisted backbone, the practice of adding vitamin D to milk was begun about 30 years ago. We call this fortified milk. This practice helped to almost wipe out rickets.

But scientists made an unexpected discovery. They found that an overdose of vitamin D can be dangerous. It can cause lumps of bone building minerals to form in wrong places and to kill a person. Scientists think the same thing can happen to a person whose skin makes too much vitamin D.

1. How can your body produce too much vitamin D even though you do not drink fortified milk or take vitamin D pills?

Sources of Vitamin D



B. THE RIGHT COLOR FOR SURVIVAL

Those of you who have ever gotten a sunburn know that ultraviolet light can be quite damaging. You have to be careful how long you stay in the sun. You also have to be careful if you live in a place where the sun's rays are most intense, like the Equator.

2. According to Darwin's explanation, what color skin would be best at the Equator?

3. Using vitamin D in your answer, explain why a darker skin would be of value to a person who lives near the Equator.

4. What would be one disadvantage for those born with lighter skin at the Equator?

5. After thousands of years, what probably happened to the skin color of those who lived at the Equator?

6. According to Darwin's explanation, what color skin would be best in a location nearer the poles such as Canada or Sweden?

7. Using vitamin D in your answer again, explain why a lighter skin would be of value to a person who lives near the poles.

8. What would be one disadvantage for a person born with darker skin in a colder, more northerly location?

9. After thousands of years, what probably happened to the skin color of those who lived in this location?

It should be pointed out that this explanation of skin coloration has been greatly simplified. Evolution is a very slow and complicated process. There are many factors that determine an individual's chance of surviving. Skin coloration is not the only factor. But all factors are determined by the same explanation given by Darwin.

10. In summary, what skin color is best in a given location?

11. Therefore, what is the reason for dark-colored skin?

12. What is the reason for medium-colored skin?

13. What is the reason for light-colored skin?

"Joe, these people say they want flesh-colored Band-Aids."

This explanation of the origin of skin coloration is only one of many. Darwin's explanation is also only one of the major explanations for evolution. Yet of all the explanations, there is no scientific data to support the idea of racial superiority. Skin coloration is a scientific happening!

CONCEPT SUMMARY.

Idea 3
Genetics

Investigation 1

And the Beat Goes On

Bacteria are so small that they can only be seen under a microscope.

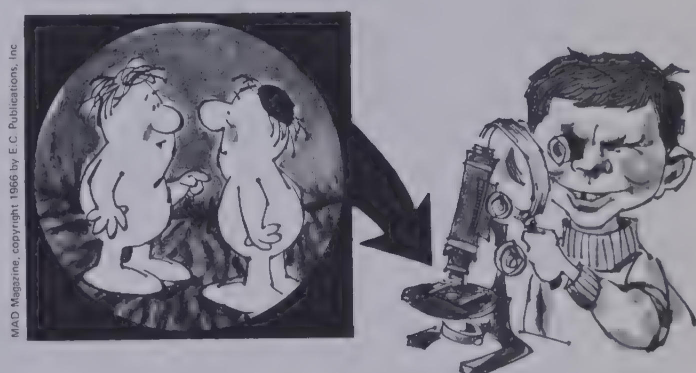
Bacteria are found everywhere–in the air, in water, and in the soil. In a previous investigation, you mixed some soil and water, and poured a few drops of the mixture in a Petri dish containing some food. Groups of bacteria were visible in a day or so.

Now you will be given four tubes of beef soup. One tube has been left open. The other three have each been capped in a different way. All four were put into a pressure cooker and sterilized to kill all forms of life.

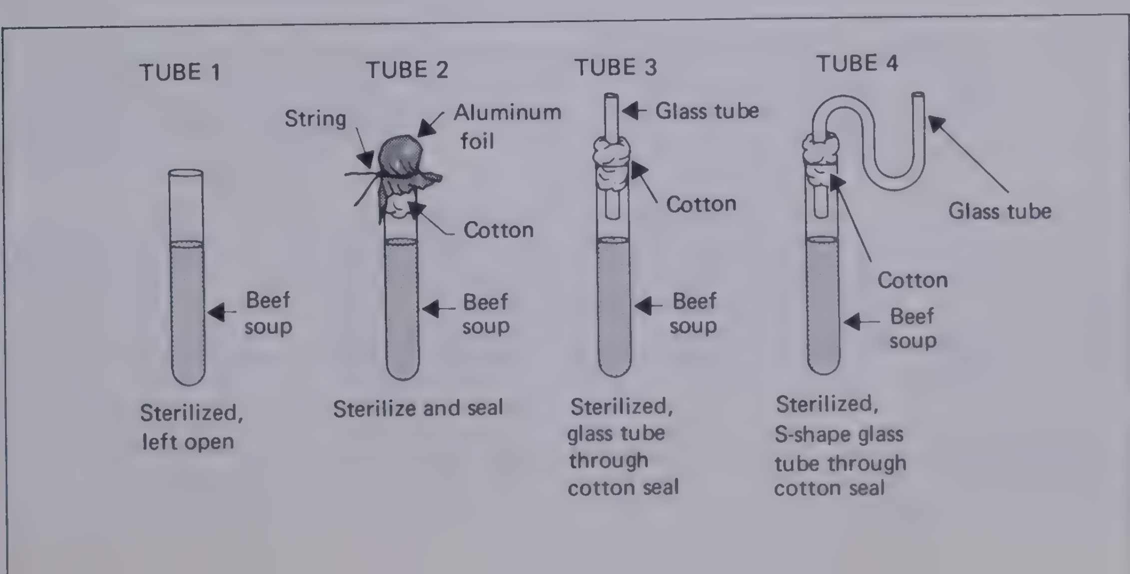
Answer the following questions in your data sheet.

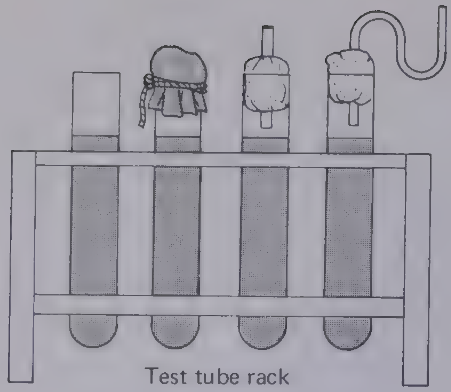
1. What color is the beef soup in each of the tubes?

2. Which test tube is the control?



That's Funny! You Don't Look Germish!





What do you predict will happen to:

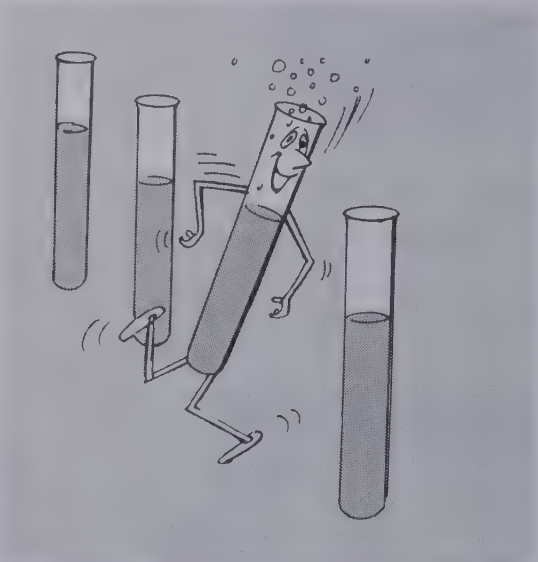
3. the liquid in tube 1?

4. the liquid in tube 2?

5. the liquid in tube 3?

6. the liquid in tube 4?

7. Do not remove any of the caps or blow into any tubes. Why?



The purpose of the beef soup is to provide food for the bacteria. The four tubes can be kept in a test tube rack or a large beaker.

Observe the tubes for 3-5 days, recording each day's observations in Table 1 on your data sheet.

8. Which tubes showed a change?

9. What do you suppose is in the tubes that showed a change?

There may be some of you who believe that life can come from something not living, such as air. Note that both tubes 3 and 4 are open to the air.

10. Describe what happened to tubes 3 and 4.

11. What do you suppose is in one tube and not the other?

12. Remember, air can enter both tubes 3 and 4. Did tube 4 show any signs of life? What can you conclude from this observation?

13. What do you suppose the crooked tubing in tube 4 prevents from entering the tube?

14. Can you conclude that there must be forms of living things too small to be seen, floating in the air? Explain why.

15. If any tube showed signs of living things, where did the life have to come from?

16. Where must living things come from?

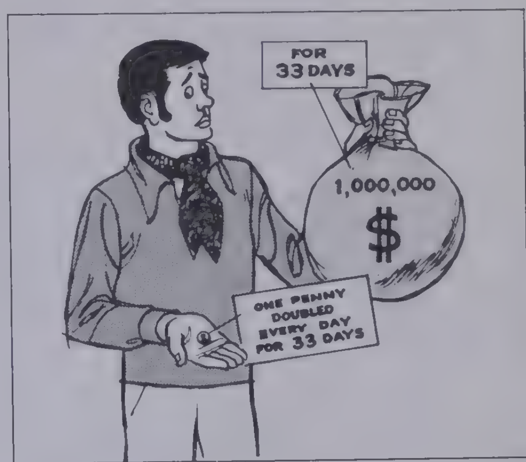
CONCEPT SUMMARY. (What general concept have you learned from this investigation?)

Investigation 2

Don't Crowd Me, Baby

Have you ever been asked, "Would you rather be paid a million dollars a day, or a penny the first day and then double the amount each succeeding day?" Since the length of time is important, let's imagine that this would happen for 33 days.

1. Which would you take?



Let's see which way would make you richer.

2. If you take a million dollars a day, how much would you have at the end of 33 days?

3. If you take a penny the first day and double the amount each succeeding day for 33 days, how much would you have? Use Table 1 for your calculations and answer.

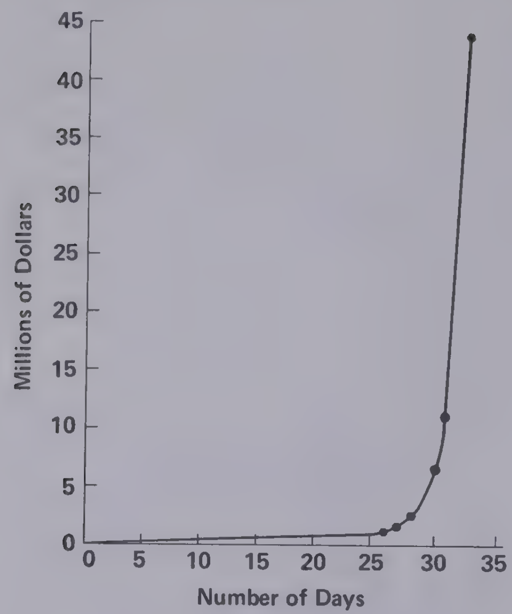
A penny is very little compared to a million dollars. But if you started with a penny and doubled it each day, you could have over a million dollars in a very short time. That's a lot of money!

A penny can grow so fast because numbers increase rapidly when you double them. Just look at your numbers in Table 1.

A. TWO NEW PETALUMAS EVERY HOUR?

In the time it has taken you to read this sentence (five seconds), about 165 more people have been added to the world's population. By the time you finish working on this investigation, about 10,500 more people will have been added. That's the equivalent of two new Petalumas every hour.

GRAPH NO. 1
THE INCREASE OF A PENNY THAT IS DOUBLED DAILY



If your data from Table 1 are plotted on a graph, it will look like Graph 1.

The increase in the world's population can be compared with the increase of the penny. Compare Graph 2 with Graph 1.

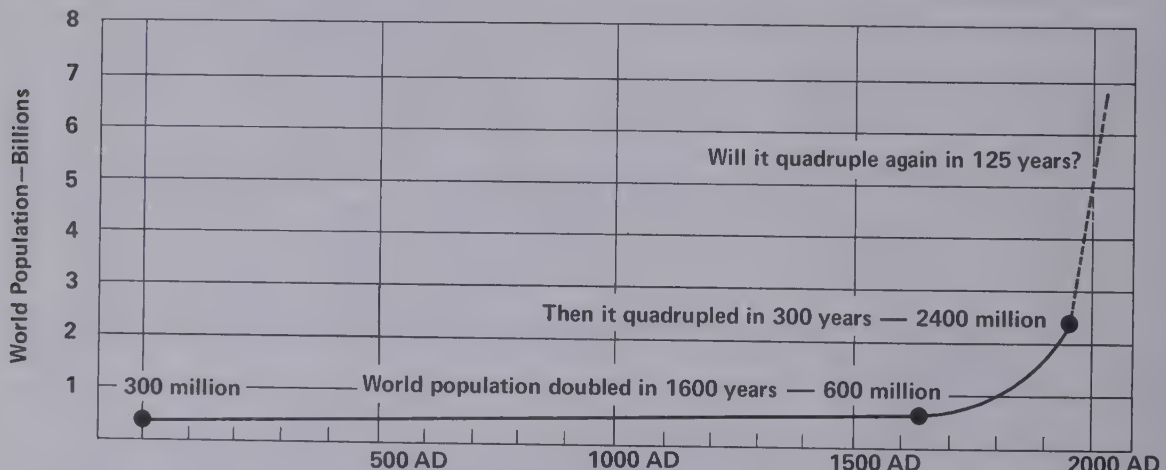
B. MOVE OVER. IT'S CROWDED IN HERE

What happens when a population becomes too crowded?

You will be instructed to use test tube 1 from the last investigation or you will be given another container of food.

4. What is the color or condition of the food?

GRAPH NO. 2
GROWTH OF WORLD POPULATION



Observe the container of food daily for at least 5-7 days. Record your observations in Table 2.

5. What happened to the color or condition of the food after several days?

6. What do you think caused the change?

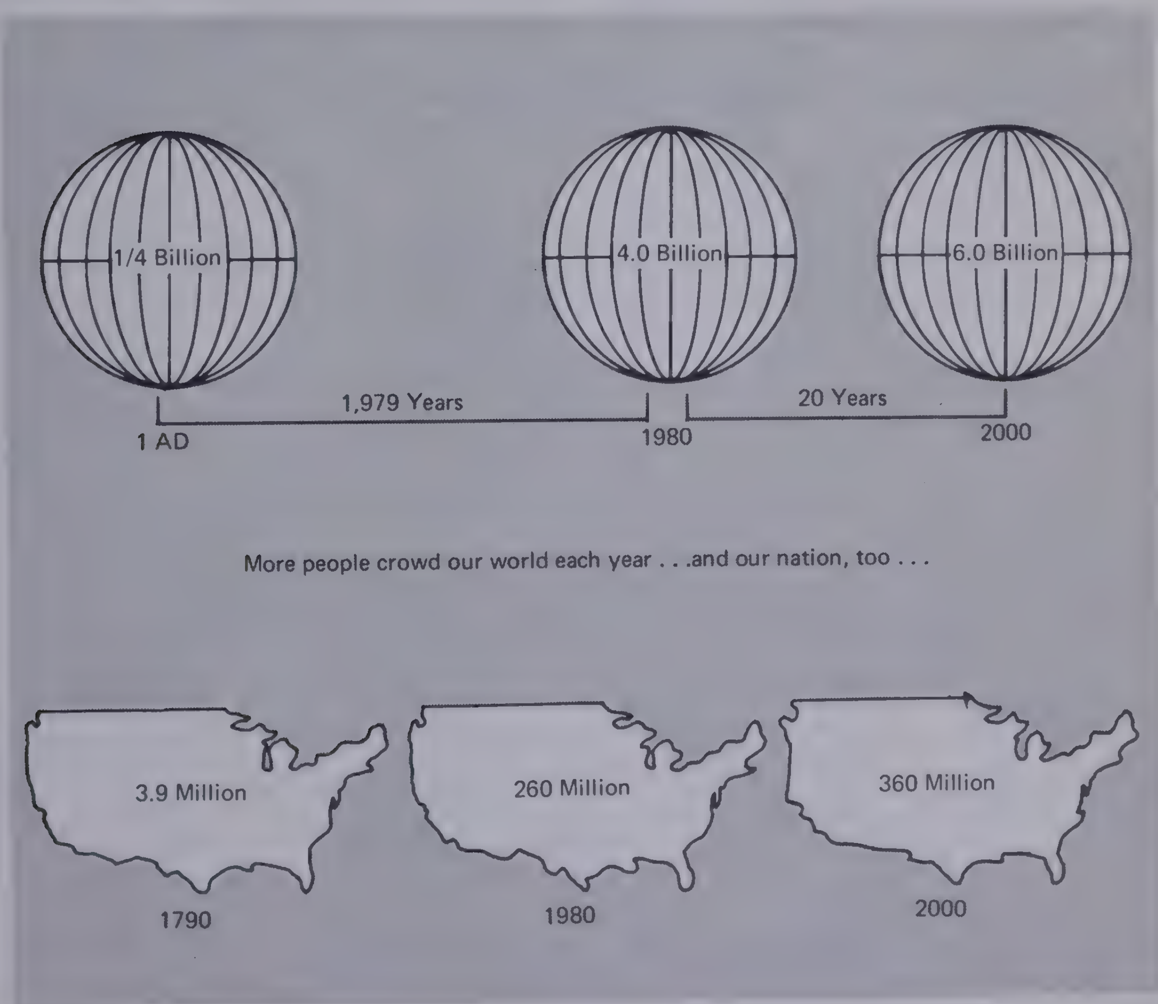
7. From your observations, what do you think can happen to a population of living things?

C. THE POPULATION BOMB

The world population now stands at more than 3.5 billion persons, an all-time record. If the present upward trend continues, this number will almost double by the year 2000.

Scientists have predicted that widespread hunger will strike us within the next 20 years. Should we do anything about it?

Population Increases in the World and in the United States



Some say we *should not control* the population growth because:

a. A sufficient number of people are necessary to support a national economy.

b. It is a man's right to have and to support children.

c. Population control is a form of genocide (the deliberate destruction of a group of people).

d. The food supply can keep up with the growth in population.

Others say we *should control* the growth of population because:

a. The growth of population will become greater than the available food supply in about 15 years.

b. It is better to improve the quality of people than the quantity of people.

c. Developments in technology will not keep up with the growth in population.

d. Overcrowding leads to a breakdown of man's environment.

What do you think?

CONCEPT SUMMARY. (What general concept have you learned from this investigation?)

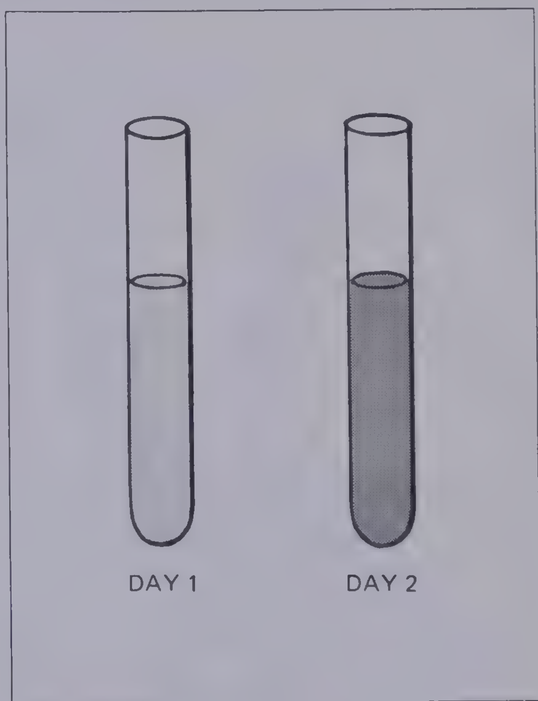
Investigation 3

Look Ma, No Pa

Bacteria are very easy to grow. Some beef soup is all you need. You found this out in Investigations 1 and 2. You now know that:

a. Life must come from previous life.

b. Some forms of life can reproduce very rapidly causing an overpopulation.

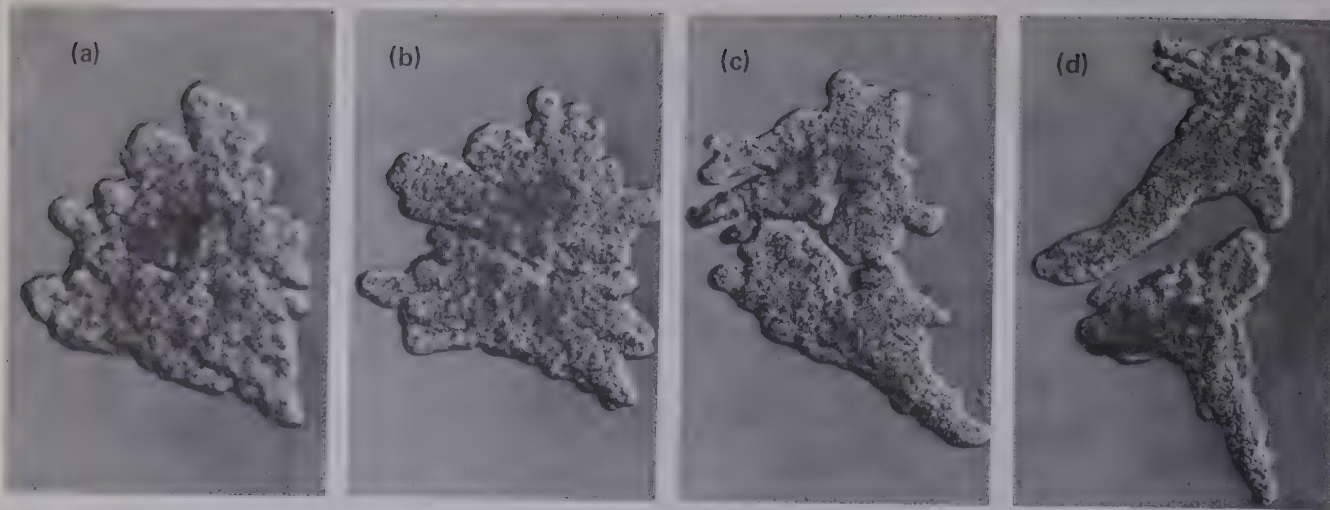


An excellent example of overpopulation can be seen when bacteria in beef soup are observed. Within a day, a test tube of beef soup will turn cloudy because of the millions of bacteria that appear.

If you start with one bacterial cell, there would be enough bacteria to give every person on earth one each in 24 hours. Thirty-six hours later, the entire surface of the earth would be covered one mile deep. In less than 100 hours, the entire solar system from the sun to Pluto would be packed.

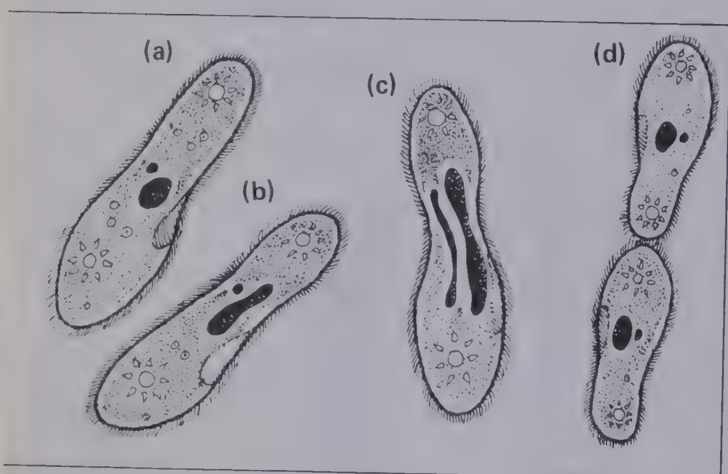
1. But this could never happen. Why?

In this investigation we will examine how bacteria reproduce. We will use ameba and paramecium to study this process.



Courtesy Carolina Biological Supply Co.

Ameba Reproducing

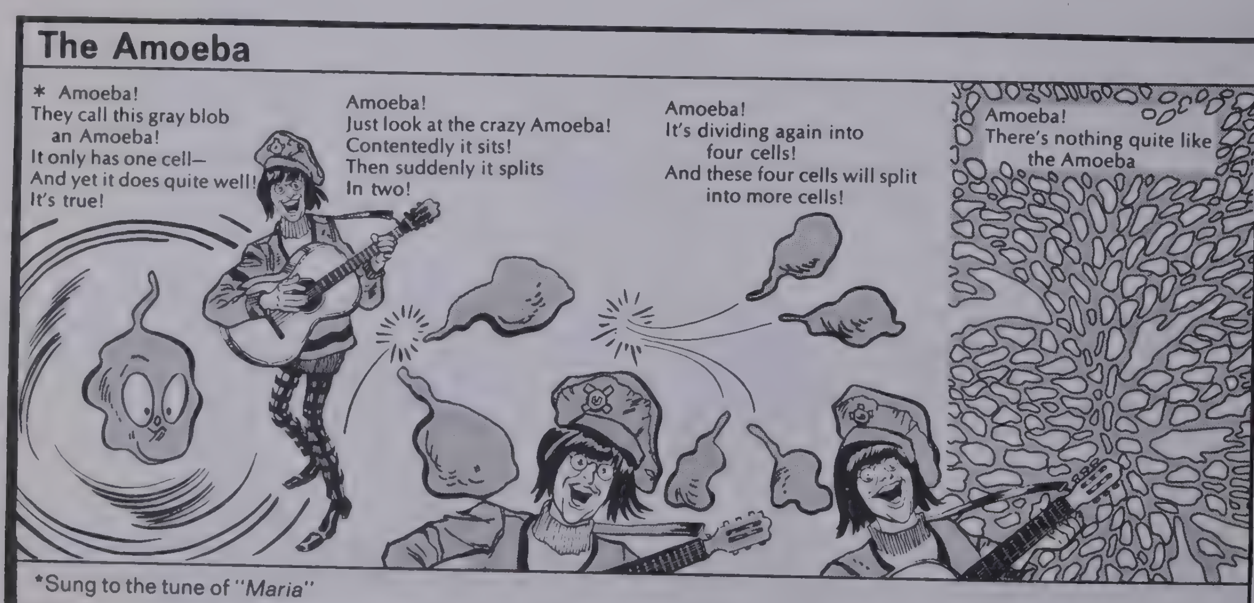


Paramecium Reproducing

A. I'M BORED, LET'S SPLIT

Study the series of photographs above and the drawing to the left. The first is of an ameba (or amoeba) and the second is of a paramecium. You may have seen these microscopic organisms when you examined the pond water in Idea 2, *Evolution*.

If they are available, look at some live amebas and paramecia and see if you can find one that is doing what is pictured above. Your teacher may also have a film loop of the sequence.



2. From what you have observed, what would you conclude is the ameba's and paramecium's method of reproduction?

3. How many parents were needed for this type of reproduction?

B. MOVE OVER, BUD

In the case of the ameba and the paramecium, the "parent" no longer exists after reproduction. Other organisms reproduce in a similar way, but the parent continues to exist after offspring are produced.

Place a drop of yeast culture on a slide and add a cover slip. Observe the yeast under the microscope. You looked at some yeast in the last Idea. It is a yellow organism shaped like an egg.

Make a drawing of some yeast in space *a* on your data sheet. Now look carefully at all the yeast and see if you can find any that have tiny buds growing out of the parent yeast. Make a drawing of these in space *b*.

4. How do you think yeast reproduce?

5. How many parents are needed for this type of reproduction?

If they are available, look at some hydra under the microscope. See if you can find a hydra like the one pictured below.

6. Describe one way the hydra reproduces.

7. How many parents are involved in this method of reproduction?

Hydra Reproducing

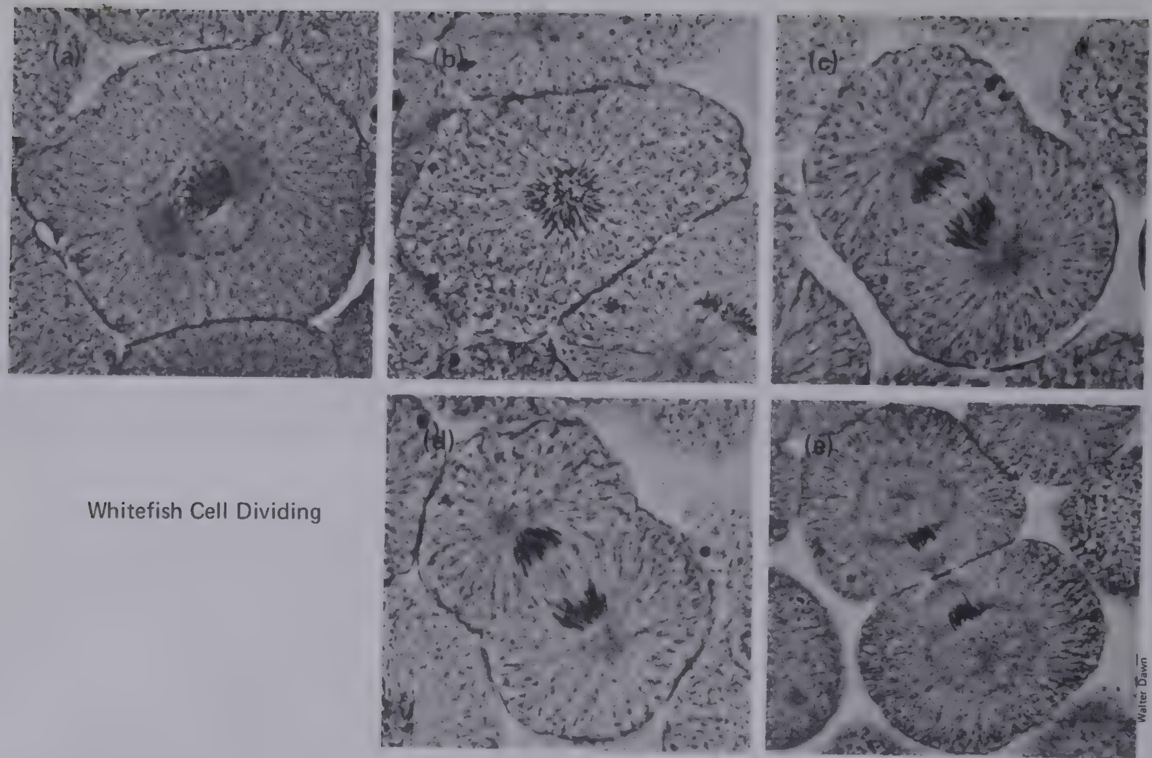
Courtesy Carolina Biological Supply Co

C. DO YOU HAVE DIVIDING PAINS?

You have already learned that all organisms are made up of one or more cells. As an organism grows, what happens to these cells?

8. As you grow from being a baby to what you are now, what do you think happens to the cells in your body?

You will be given a slide that has been prepared from a section of an onion root tip. As you look at the cells, note that all of the cells do not look alike. The different colors that you see are stains that have been added to the cells to make certain parts easier to see.



Whitefish Cell Dividing

In space *c* on your data sheet, make an outline drawing of the shape of the onion root tip.

Look at your slide and see if you can find cells that match the cells pictured above. Make a drawing of each of the cells in the onion root tip. Letter each cell to match the letter in the picture.

As you look at the slide, notice that many of the cells do not have stained parts inside them.

9. What do you think is happening to the cells that have stained parts inside them?

10. How many parents are involved in this method of reproduction?

11. What have you learned from this investigation about how some organisms and cells reproduce?

12. What do you think is meant by the title of this investigation, "Look Ma, No Pa"?

13. Would you happen to know the word for the type of reproduction we have been studying? If so, what is it?

CONCEPT SUMMARY. (What general concept have you learned from this investigation?)

Investigation 4

Don't Peas Come in Cans?

There are many organisms that reproduce by dividing. This is the type of reproduction used by most one-celled organisms. When the cell splits in two, each half receives an equal part of the parent cell. The halves, or offspring, look like the parent. In addition, each half receives an equal part of the nucleus of the parent.

Some organisms, like yeast and hydra, can reproduce a whole new organism from a part.

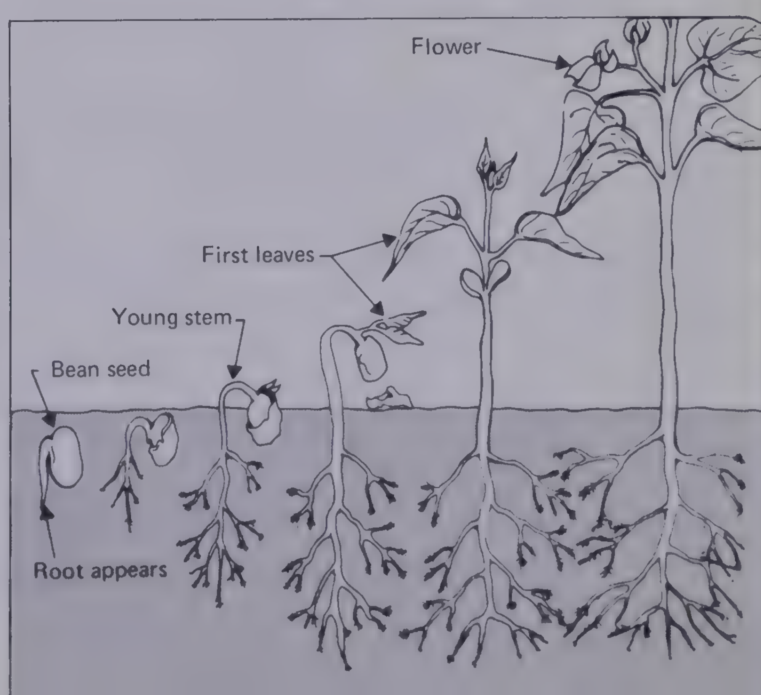
When an organism reproduces by dividing or by producing a whole from a part, there is only one parent involved. The parent and the offspring are without sex. We call this type of reproduction *asexual.*

I'm Bored. . .Let's Split!

Yeast Reproducing

A. WHERE DO SEEDS COME FROM?

If you plant a bean seed, the seed will grow into a bean plant. First, the root will develop, then the stem will appear. Leaves will appear on the stems, and flowers will follow. Where do the seeds come from? What kind of reproduction is used by the bean plant?

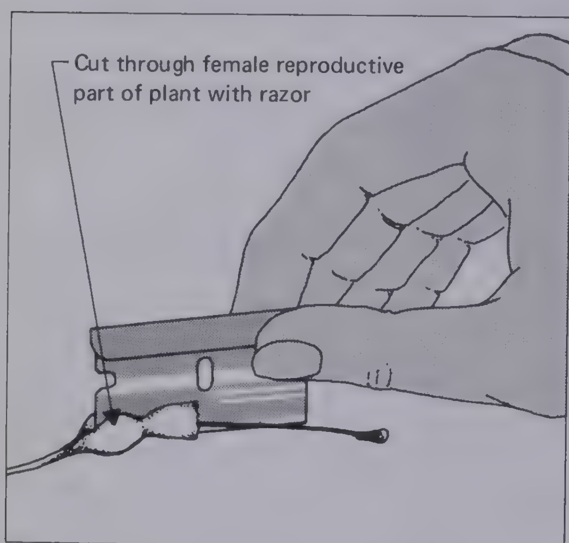


Remove all the petals of a flower until just the central part remains in your hand. Make a drawing of this part in space *a*.

Find the many stalks that stick out of the central part. There will be one central stalk that is larger than the other stalks. Note the fine powder at the ends of these smaller stalks. This powder is called pollen or pollen grains. Pollen grains are male reproductive cells. Label the stalks "male reproductive organ" and the powder "pollen" in your drawing.

Use your forceps to gently remove the male reproductive parts. You will need them in part B. You now have a central stalk sticking out of the base. The stalk and the base are the female reproductive parts of the plant.

Using a razor blade, carefully cut the base in half lengthwise as shown below. (Do this on the wood block provided.)



Examine the cut surface of the base with a hand lens. Look for some round or oval structures. These are the female reproductive cells or eggs. The part which holds the round or oval structures is called the ovary.

Make a drawing of the cut half in space *b*.

Label the large center stalk "female reproductive organ." Label, also, the "ovary" and the "eggs" in your drawing.

You have now found the location of the male and female reproductive cells. How do these two parts get together?

B. ARE ALL APPLES FEMALES?

You will be given a Petri dish containing a sugar solution. A small amount of agar has been added so that it will set like a gelatin dessert. Place a few drops of distilled water in the dish. Tip the dish around in your hand to spread the water over the agar surface.

Sprinkle some pollen grains into the dish. Make a drawing of what you see in space *c*. Then set the dish in a warm, dim place for 24 hours.

The next day, examine your plate of pollen grains. Make a drawing of what happened in space *d*. (If nothing happened in your dish, check with some of your classmates. Find a dish where something happened and draw it in space *d*.)

1. Describe the difference between the pollen grains in drawings *c* and *d*.

Let's try to figure out what is happening. The pollen or male reproductive cell is produced by the many smaller stalks that surround the larger, central stalk. Review this by taking a look at your drawings again or examine a fresh flower.

2. Find the larger, central stalk. Do you find any pollen grains on the tip of this stalk? How do you think they got there?

Remember that you sprinkled pollen grains into a Petri dish containing a sugar solution.

3. What do you predict the tip of the larger, central stalk secretes (gives off)?

4. What do you think this would cause the pollen grains to do?

5. How do you think the male reproductive cell reaches the female reproductive cell in a plant?

After the pollen unites with the egg, the egg cell divides in half, then again, and again, and so forth. Pretty soon, the egg, which was so small a microscope had to be used to see it, becomes a seed. The ovary, which surrounded the egg, grows and becomes the fruit.

The circle of life is complete. If the seed is planted, a whole new plant will appear.

Thus, you can see that peas do not mysteriously appear on the dinner table from cans or frozen food boxes. They are the result of a form of reproduction.

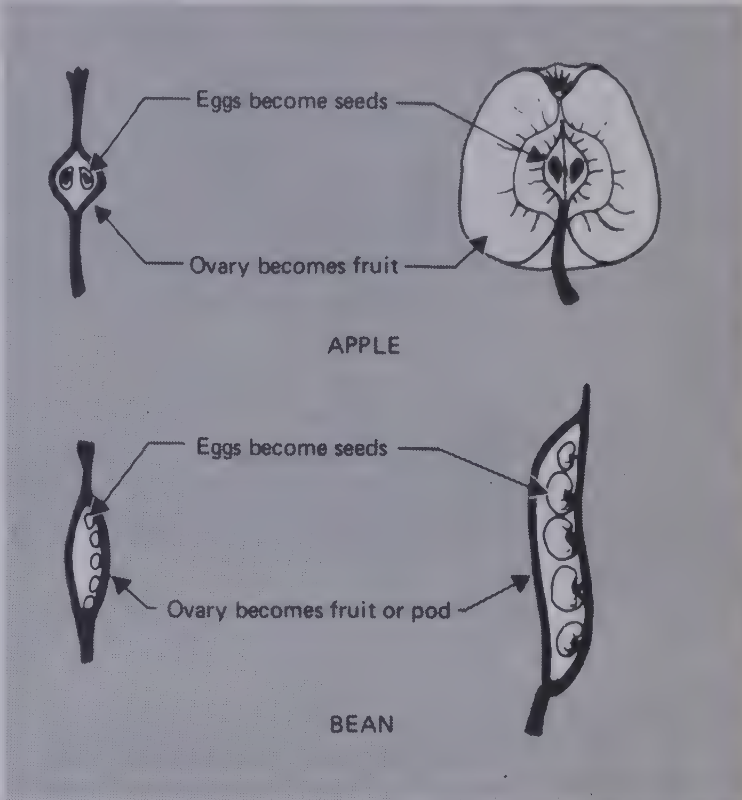
6. Do you know the name of this type of reproduction? If so, name it.

Thus, we have studied two types of reproduction. In asexual reproduction, new offspring are formed by splitting cells.

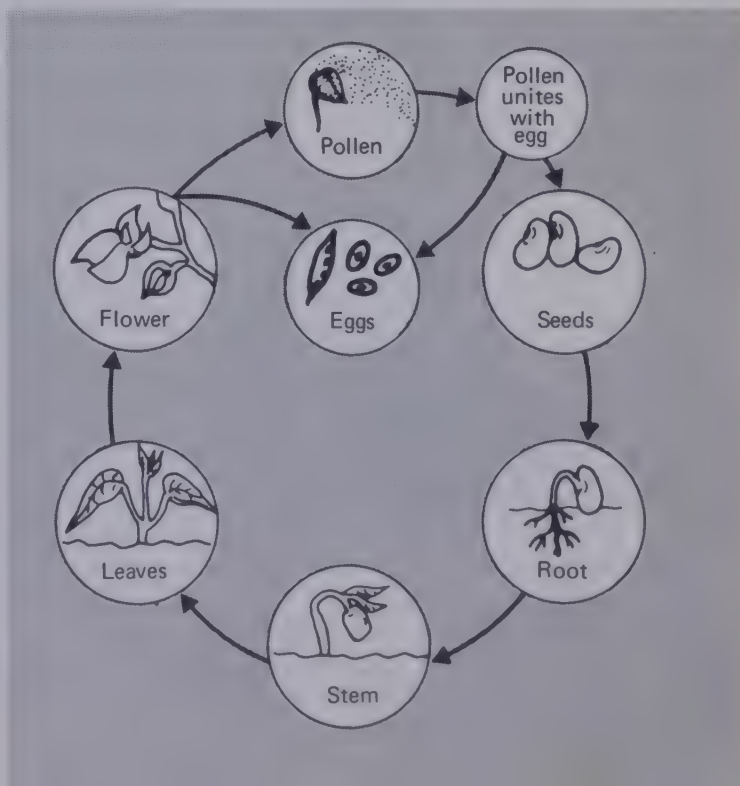
7. In sexual reproduction, new offspring are formed by __?__

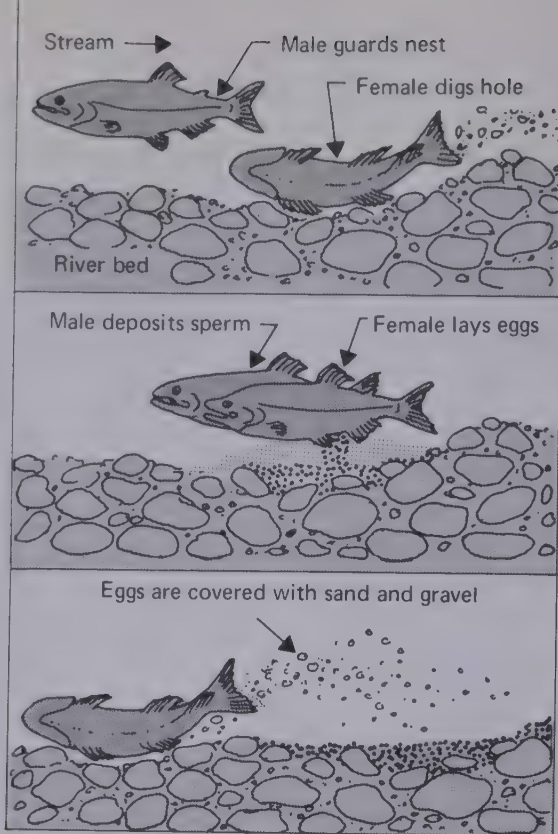
You will be shown some bean and pea seeds.

8. Do the bean seeds look alike? Describe the seeds.



Plant Life Cycle





9. Do the pea seeds look alike? Describe the seeds.

10. The pea and bean seeds were the result of what kind of reproduction?

11. In asexual reproduction, how do the offspring look compared to the parent?

12. In sexual reproduction, how do the offspring look compared to the parent?

C. AND THEN THERE IS THE STORK?

Animal reproduction follows the same pattern as plant reproduction. In the beginning, life starts as a tiny egg cell. If a sperm cell meets the egg cell, the process of sexual reproduction begins. However, it is not all that simple.

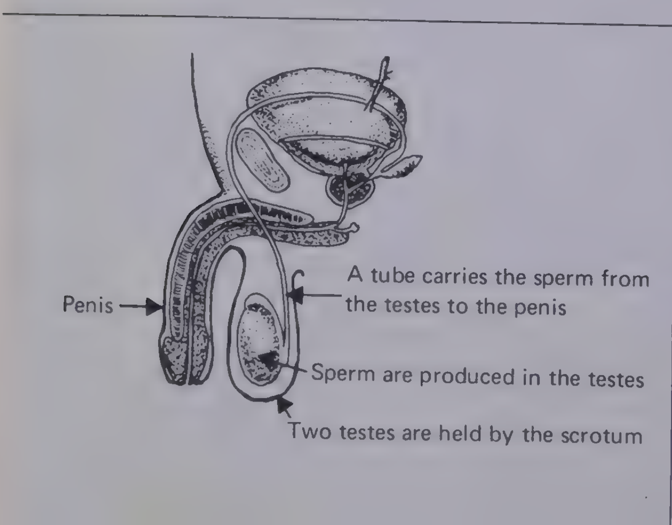
Many fishes and amphibians lay their eggs out in the open. For instance, some female fish lay their eggs in a mud hole. The male swims over the eggs and deposits the sperm. We call this *external fertilization.*

On the other hand, most reptiles, birds, and mammals have their eggs fertilized inside the female.

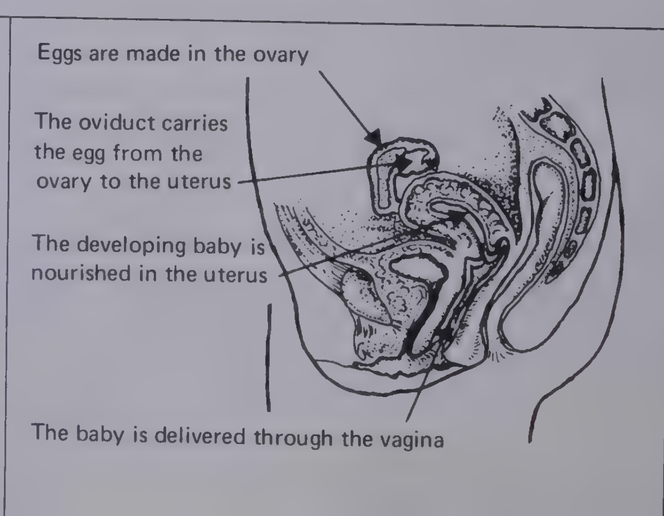
In the human male, the sperm cells are made continually. In the human female, the egg may not always be present. Let's see why.

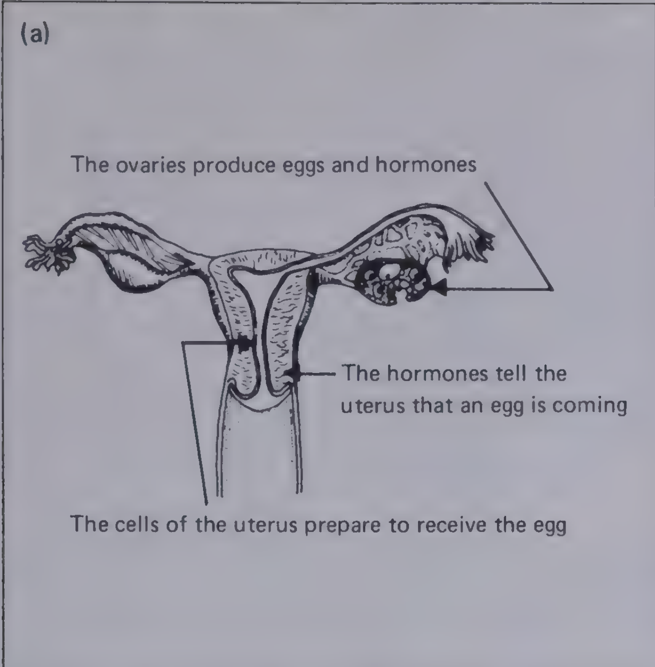
The human female has two ovaries. These ovaries alternately produce an egg and chemicals we call hormones. Hormones are like little messengers. They "tell" different parts of the body what to do.

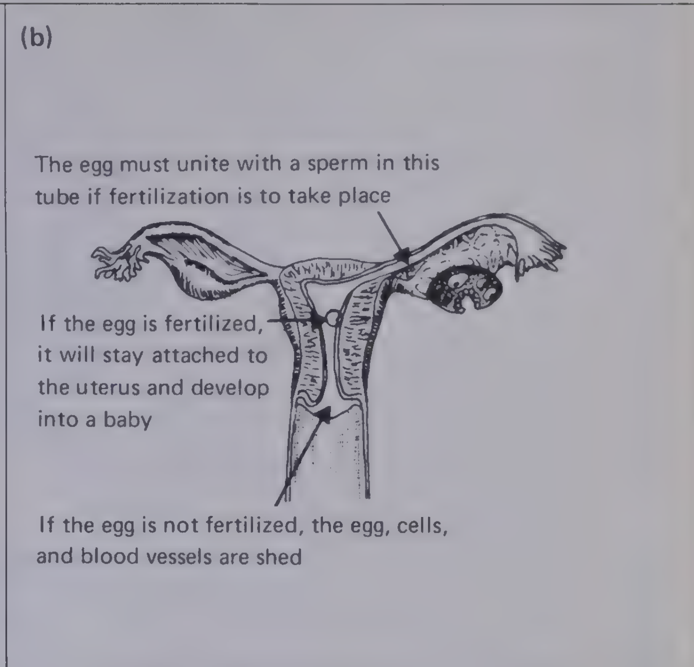
Male Reproductive System



Female Reproductive System







One hormone "tells" the uterus that an egg may be coming. The cells on the surface of the uterus multiply rapidly and become prepared to receive the egg. New blood vessels are also formed to feed the new cells.

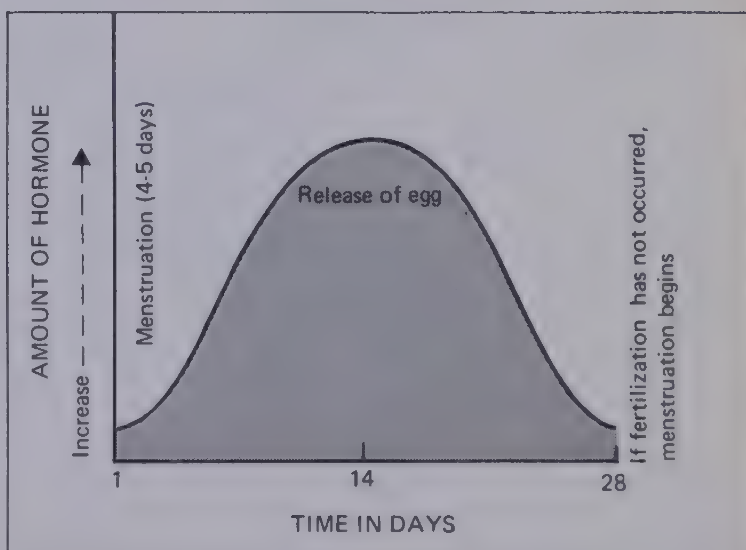
When the uterus is ready to receive the egg, a hormone signals the ovary and usually one egg is released.

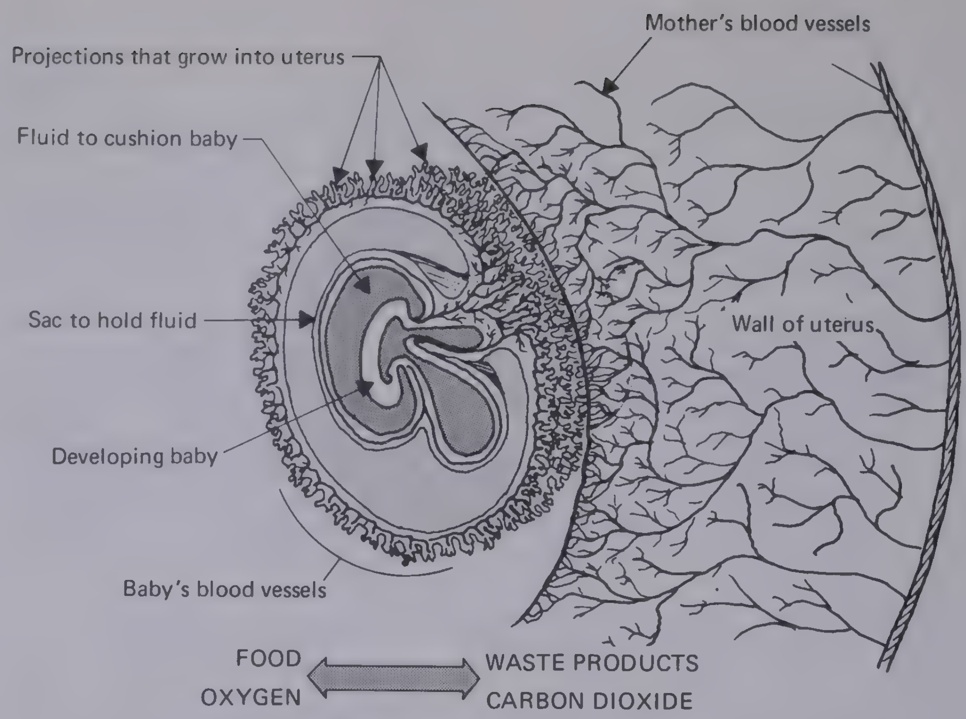
The egg moves slowly down a tube to the uterus. If a sperm is to fertilize the egg, it must do so during the 3-5 days the egg takes to travel down the tube.

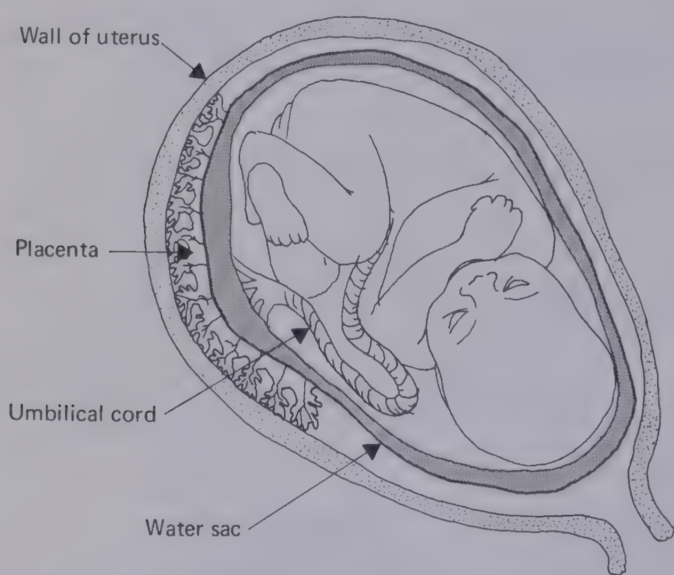
If the egg is not fertilized, the egg and the layer of new cells and its blood vessels are shed from the body about 14 days later. This is menstruation. Hormones, again, tell the body that fertilization did not take place.

Therefore, the human female normally has a monthly cycle that can be summarized by the diagram to the right.

If the egg is fertilized, the monthly cycle stops and pregnancy begins. The egg cell begins to divide and divide. From these cells will come not only the baby itself, but also the bag within which the baby develops.







FULL TERM NINE MONTHS

The place where the baby and the uterus of the mother join is called the *placenta.* Here the blood system of the baby and the mother are next to each other, but never joined. Food and oxygen pass from the mother's bloodstream to the baby's bloodstream. The baby, in turn, passes waste products and carbon dioxide to the mother.

And in about nine months for humans, a miracle indeed occurs, a miracle that should not be taken lightly. What was once a tiny fertilized egg cell is now a baby.

13. To summarize, in sexual reproduction how many sex cells join together?

14. What do the offspring look like as compared with the parents?

CONCEPT SUMMARY.

Investigation 4A

The Epidemic No One Talks About

Do you know what disease strikes a teen-ager every nine minutes?

Do you know what disease:

a. Infects an estimated million people each year?

b. Kills about 3,000 people each year?

c. Strikes 800 young people between the ages of 12-19 every day?

Perhaps the most serious disease of the reproductive system is VD or *venereal disease.* Two new cases of VD develop every minute. Of the estimated one million new cases of VD each year in the United States, 300,000 are teen-agers. This is a genuine epidemic that has become too serious to ignore.

Many people think that delinquency, narcotics, and illegitimacy are the big hang-ups of today's teen-agers. Yet the biggest hang-up is VD.

The number of new VD cases has been rising steadily for the past ten years. The sharpest jump is among juveniles, especially in the 10-14 age group.

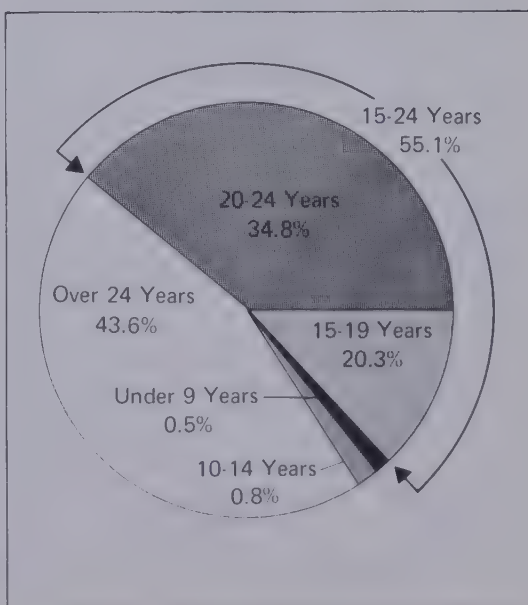
As you can see by Graph 1, over half of the venereal disease cases are found in people between the ages of 15-24.

One of these venereal diseases, syphilis, is increasing at a faster rate among teen-age boys and girls from 15-19 years of age than in any other age group.

Another venereal disease, gonorrhea, infects 1 out of every 200 teen-age boys, and 1 out of every 400 teen-age girls annually.

Each year about 3,000 people die of syphilis in the United States. An infection of syphilis or gonorrhea can leave you crippled and childless for life.

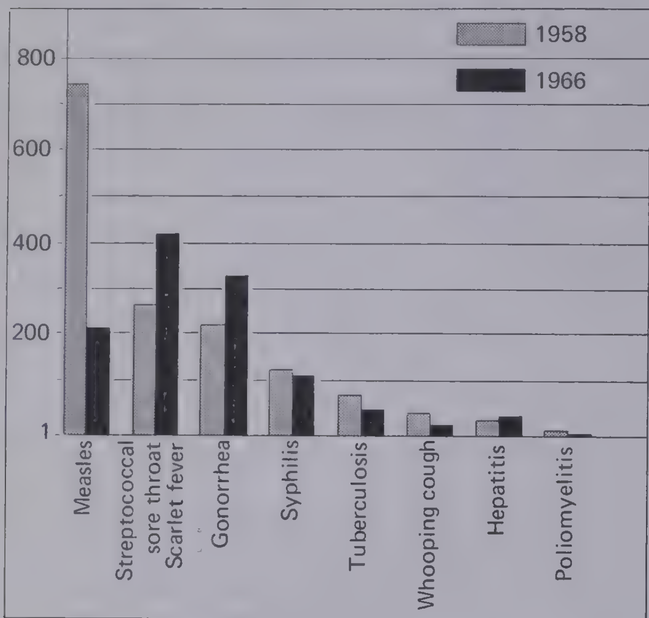
GRAPH NO. 1



GRAPH NO. 2

THE LEADING COMMUNICABLE DISEASES IN 1958 AND 1966

Reported cases, stated in 1,000's



Gonorrhea and syphilis are caused by bacteria. As you can see by Graph 2, gonorrhea and syphilis are the number two and four leading communicable diseases in the United States. A communicable disease is one that can be spread from one person to another. Strep throat, scarlet fever, tuberculosis, and whooping cough are spread by bacteria that float in the air. Measles, hepatitis, and polio are spread by a "germ" called a virus.

A. HOW IS VD SPREAD?

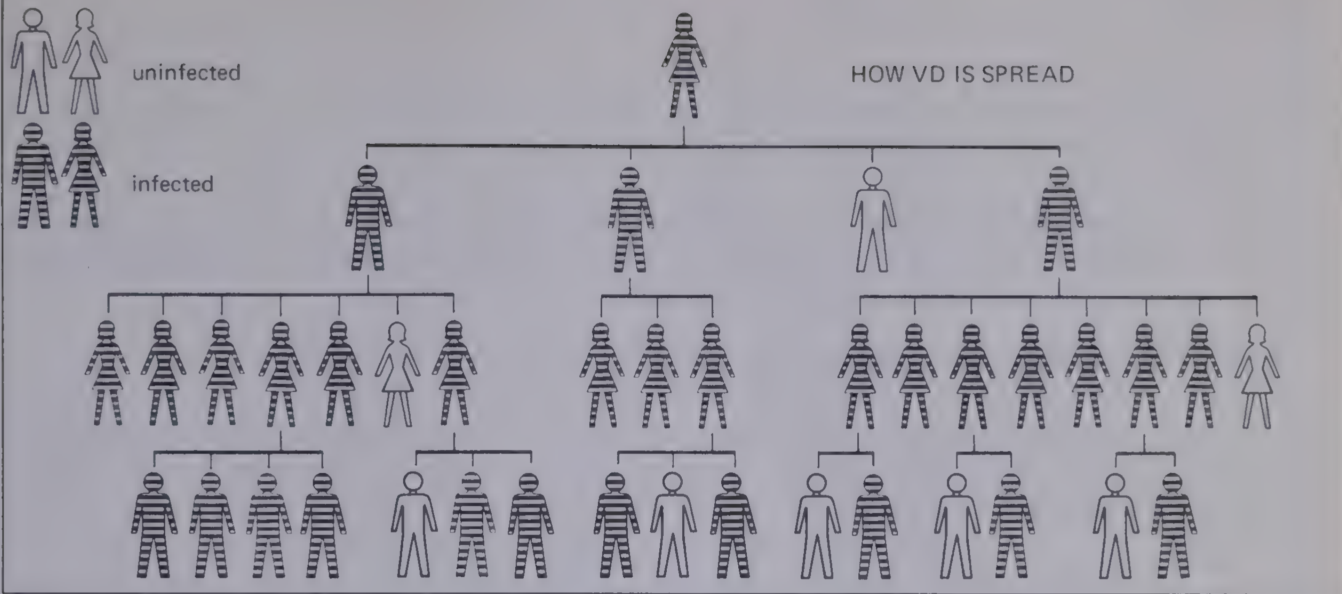
The bacteria that cause gonorrhea and syphilis, however, are not spread by floating in the air. Both of these bacteria die immediately in the air. They require the warmth of body temperatures to stay alive. For this reason, venereal diseases are spread during sexual intercourse. Other means, such as sharing a drinking cup, kissing, and using a contaminated toilet seat are very rare.

Spirochetes—Bacteria that Cause Syphilis

Communicable Disease Center, U.S. Dept. of Health, Education, & Welfare

Gonococci—Bacteria that Cause Gonorrhea

New York City Dept. of Health



To show how fast VD can spread, study the diagram above.

B. WHAT DOES VD LOOK LIKE?

VD is deadly because the dangerous symptoms do not show up for years. It's not unlike the relationship between smoking and lung cancer. In the early stages of VD, there may be a mild rash or sore on the sex organs. There may also be a discharge from the sex organs. This discharge, called "morning dew" or "the drip" in slang, is caused by the many dead germs and white blood cells that form pus.

The signs of gonorrhea usually appear 3-7 days after infection. They are more obvious in men than in women. A man will notice a pus discharge from the sex organ and a painful burning sensation during urination. A woman will have great pain when the disease attacks the oviducts of her reproductive system.

The signs of syphilis usually appear about three weeks after infection. The first sign is often a sore on, in, or around the sex organs at the point of infection. It's usually a round ulcerous lump with red edges. In a woman, this sore may be hidden deep inside the reproductive organs where it cannot be seen. It will usually disappear by itself, leading the victim to think that the trouble is over. It is not; infection is silently spreading.

The signs then disappear for years. This is why VD is so frightening; it fools people. A person can go on for years, spread the disease, and never know that he is carrying VD. All the while, the cells in the reproductive system and the nervous system are being attacked.

About nine weeks later–it varies–syphilis enters its secondary stage when it is highly infectious. At this stage, the symptoms include rashes, loss of hair, fever, sore throat, mouth sores, and splitting headaches. These symptoms, too, disappear by themselves. But the disease remains in the body, spreading secretly for 5-25 years, attacking organs and the nervous system before suddenly erupting again in insanity, blindness, paralysis, or a fatal heart attack.

Anyone who ignores the early symptoms of syphilis may become one of the 3,000 Americans each year who needlessly dies of the disease.

Some teen-agers make the mistake of thinking that gonorrhea is no more serious than a bad cold. The truth is that if gonorrhea symptoms are ignored, gonorrhea can also have serious effects—painful arthritis, blindness, sterility, and sometimes death.

C. WHAT SHOULD YOU DO?

The best medicine for any disease is preventive medicine. If the infection of VD is spread by sexual contact, it follows that sexual relations with any person other than one's wife or husband should be avoided.

If a teen-ager thinks that he may have VD, he should get medical help. Treatment should be started as soon as possible—before the disease spreads.

Investigation 5

That's Using the Old Bean

You have learned that there are two kinds of reproduction, asexual and sexual.

In asexual reproduction, there is only one parent cell which produces offspring that resemble the parent. There is practically no change from parent to offspring.

In sexual reproduction, there are two cells involved as the parents. Offspring are produced by the joining of these two cells. The offspring will not look exactly like either parent. Thus, a change takes place from parent to offspring.

This brings up some interesting problems:

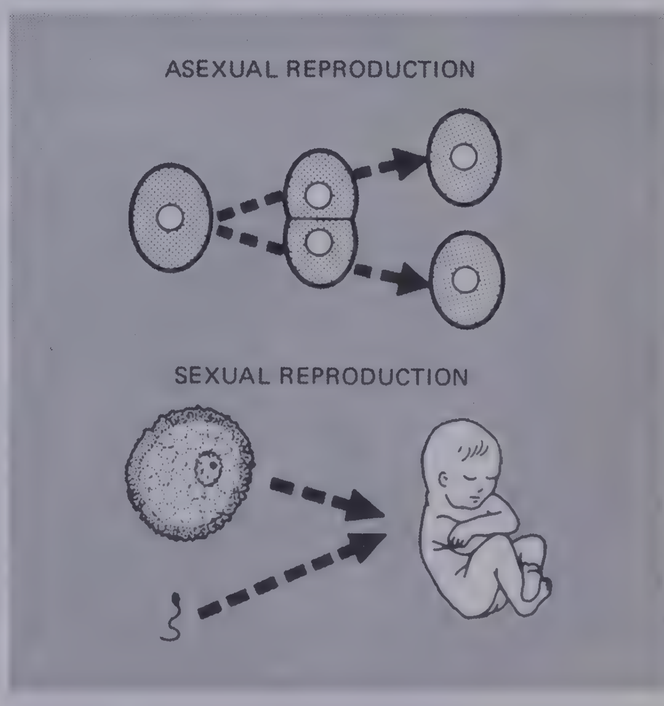
a. Why do the offspring look like the parent in asexual reproduction?

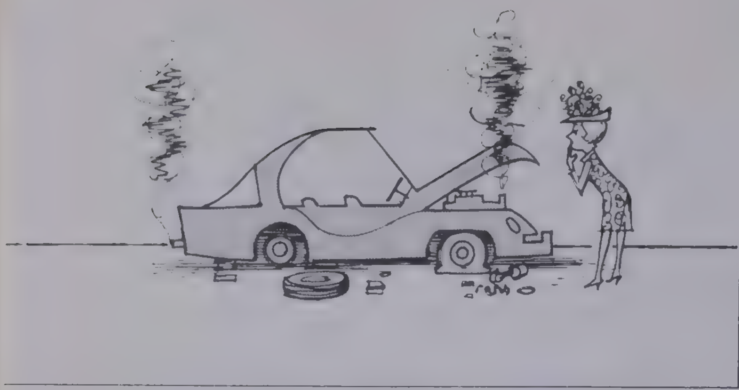
b. Why do the offspring often look different from the parents in sexual reproduction?

c. How does a cell "know" what it is supposed to become?

d. How are features passed on from generation to generation?

These are some of the problems you will attempt to solve in the rest of the investigations.





A. LISTEN TO MY CAR KNOCK

How do you solve a problem?

As you learned in Idea 1, *Inquiry,* you must recognize a problem before you can solve it. In other words, you can't have an answer unless you have a question.

A mechanic cannot fix a car until he can find the problem. He may watch gauges that are hooked to parts of the car. By watching the *pattern* of the gauges, he may be able to find the problem.

A doctor listens to heart sounds. From the *pattern* of the heart sounds, he may be able to diagnose part of the problem.

Dennis Brack from Black Star

Even a good baseball player who is in a batting slump will use the same approach. He will study video-tape television playbacks (like instant replay on TV) of his swing. From the *pattern* of his swing, he and the coaches may be able to solve his problem.

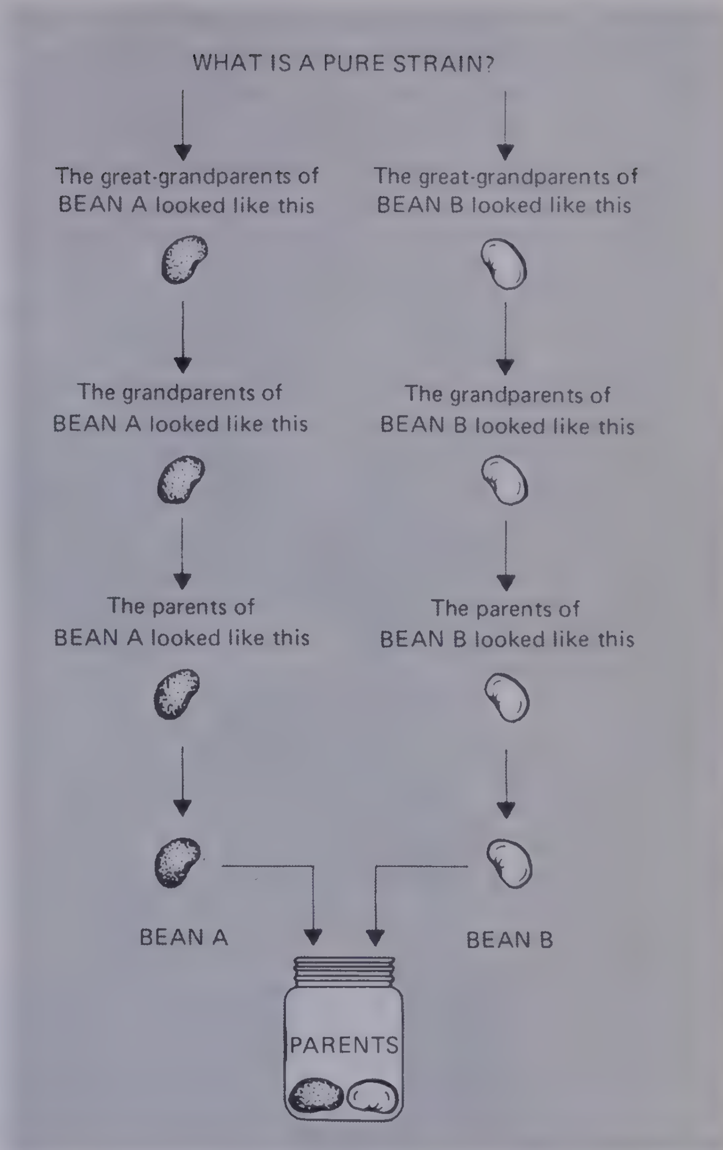
Wide World Photos

Hella Hammid from Rapho-Guillumette

B. LET'S TAKE A BEAN POLL

You will be given some beans in three different containers. The first container will be labeled, "Parents." The second container will be labeled, "First Crop." The third container will be labeled, "Second Crop."

Open the first container labeled "Parents" and examine the color of the beans. Each bean represents a *pure strain*. This means that every bean of this type has always had the same color. If the bean is planted, every new bean will be of the same color. The parents, grandparents, great-grandparents, and so forth, were also of the same color.



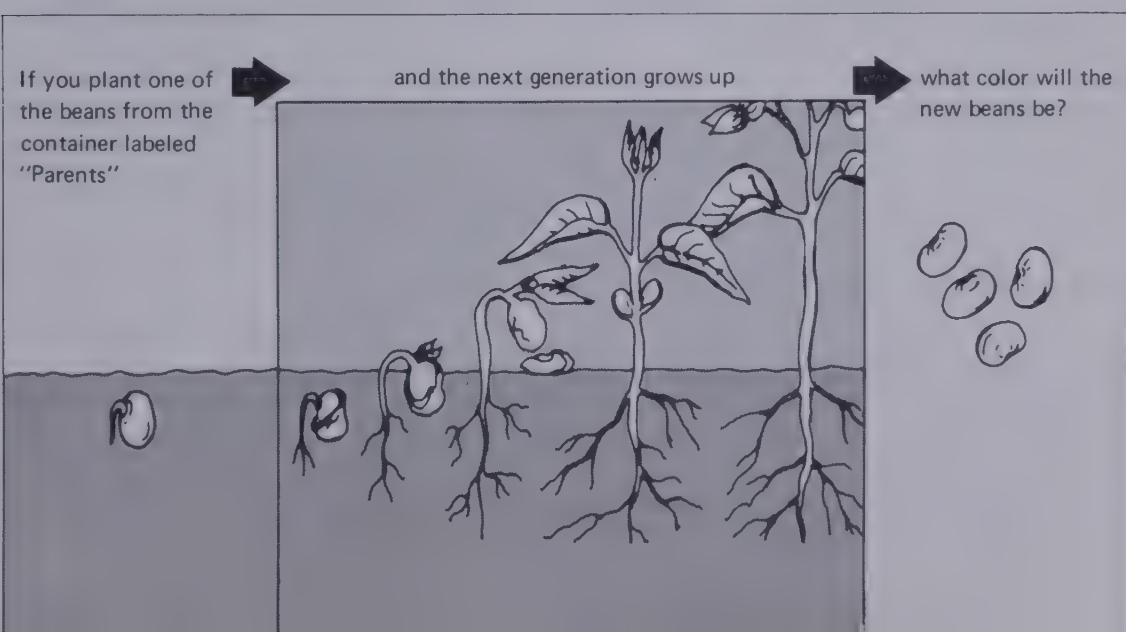
1. What color are the two beans in the container labeled "Parents"?

2. If you were to plant one of the beans, what would be the color of the beans in the next generation?

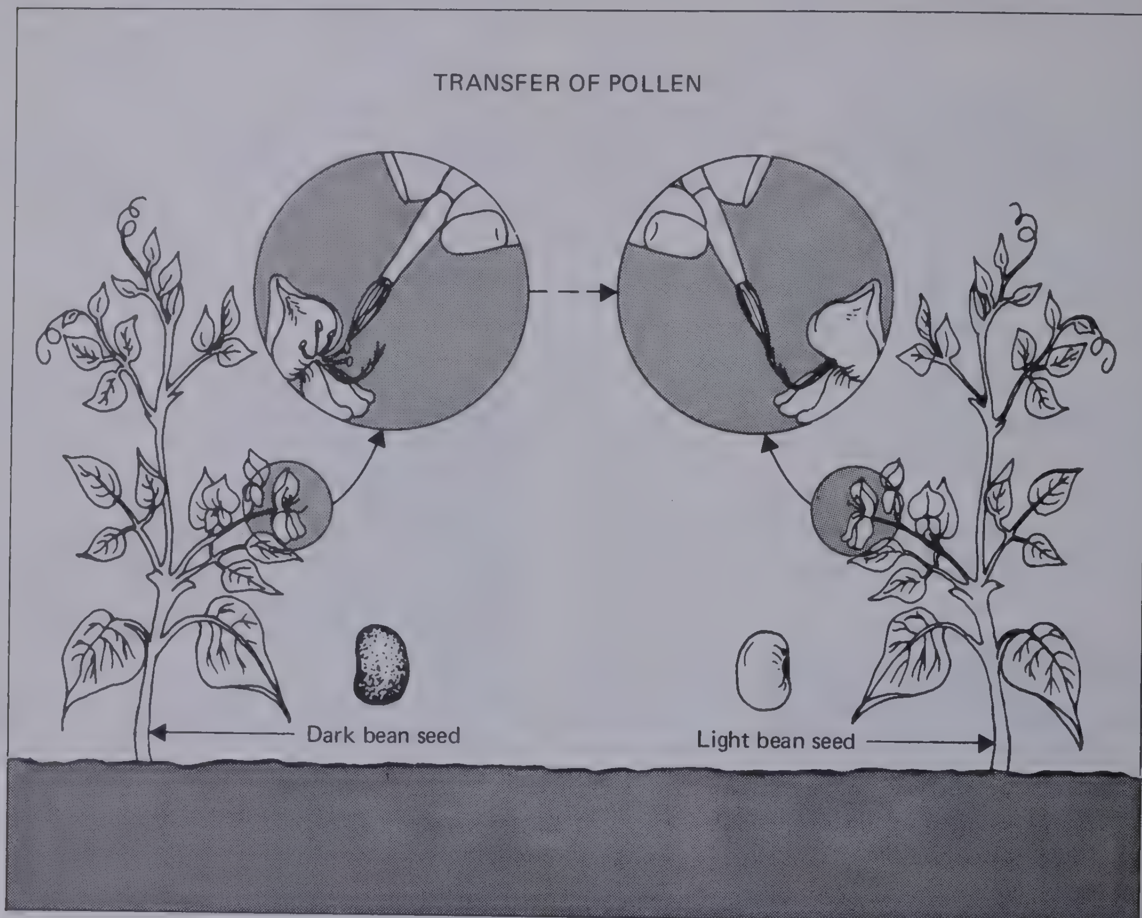
3. Why did you give this answer? Hint: What do you already know about the beans?

4. If you were to plant the other bean, what would be the color of the beans in the next generation?

5. Why did you give this answer?



Now imagine that both seeds were planted side by side. Both plants grew and flowered. Some pollen from the flower on the dark bean plant was brushed on the flower of the light bean plant. Then the male reproductive parts on the light bean plant were removed and the plant was isolated from other plants. (This was done to be certain that only the pollen from the dark bean plant was in contact with the light bean plant.)



After the flowers wilted, bean pods appeared. The pods were picked, split open, and the "First Crop" of beans collected.

A part of this crop is in the container labeled "First Crop." Open this container and examine the color of the beans.

6. Describe the color of the beans in the container labeled "First Crop."

7. Which "Parent" do all the beans of the "First Crop" look like?

8. Did a feature disappear in the "First Crop"? If so, which one?

Please return all the beans to the container labeled "First Crop."

Let's try one more crop. This time, imagine that only the beans from the "First Crop" were planted. After these beans grew and the bean pods appeared, the bean seeds were collected. A part of these beans is in the container labeled "Second Crop."

9. Before you open the container, what color do you think the beans will be?

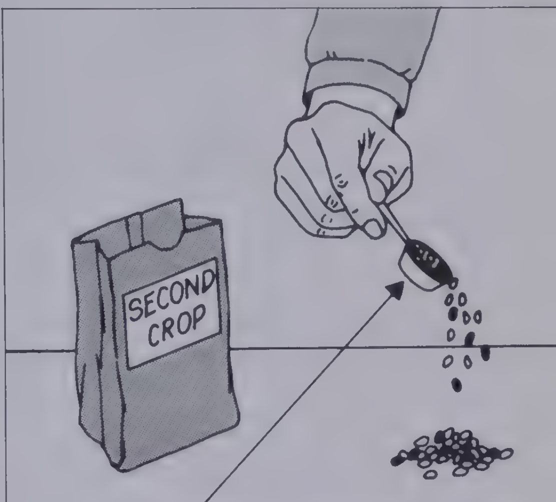
Open the container, but *do not* pour the beans out.

10. What colors are the beans?

11. What feature has reappeared in the "Second Crop"?

12. In the "Second Crop" which color seems to appear more often? Less often?

Let's see how often the two colors appear by taking a "bean poll." Stir or mix the beans in the container labeled "Second Crop." Without looking, take out six scoopfuls of beans.



Measure out six scoopfuls of beans

The six scoopfuls of beans are a sample of your bag of beans. The bag of beans represents a small portion of the entire second crop.

Count the kinds of beans present in your sample and record the results in Table 1 on your data sheet.

Obtain a sample count of the beans from three other classmates and record this in Table 1.

Complete the table by determining the ratios requested in the last column. To determine a ratio, divide both numbers by the smaller.

For instance: $\frac{476}{154}$ to $\frac{154}{154}$ = _____ to _____

Round off to the nearest whole number.

13. Look at the data in Table 1. How many more times does one color occur in your sample than the other color?

Summarize the complete results of the experiment in Diagram 1. (The "x" is a symbol for "mating" or "crossing.")

Look at the diagram you have just completed. The diagram represents a *pattern of inheritance.* Inheritance is the study of how features are passed from one generation to the next. People who study inheritance look for patterns.

Is there a pattern? Do you see the pattern?

C. TO REVIEW YOUR BEAN POLL

14. What do you call a feature that repeats itself every generation?

15. When you cross two different pure strains, what may happen in the first generation?

16. If you cross the members of the first generation with each other, what may happen in the second generation?

17. In this investigation, have you seen a definite pattern of inheritance? Explain.

CONCEPT SUMMARY.

Investigation 6

Let's Have a Pea Pickin' Time

Sylvia Anderson likes to sew. She can even design and draw her own patterns. With a pattern, she can make more than one dress and all of them will be the same size. She uses a pattern to get the same results over and over again.

1, 2, 3–6, 7, 8–11, 12, 13–Do you know what three numbers come next? Look at the pattern that developed. A *pattern* is something that repeats itself over and over again.

In the last investigation you learned that there can be patterns of inheritance.

1. When you plant a pure strain of beans, what kind of offspring will you get?

2. When you cross two different pure strains, what kind of offspring will you probably get?

3. Then if you mated the offspring from "2" to each other, what kind of offspring would you get?

Can this same pattern be applied to other plants and animals?

A. AREN'T ALL PEAS GREEN?

You will be given six packages. Open package 1 and empty the contents into a dish.

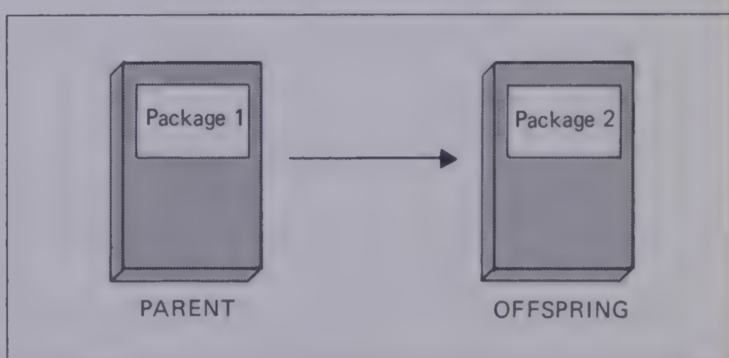
4. Name at least two features that are similar in all the peas.

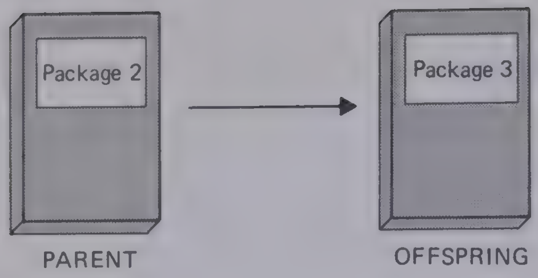
5. Can you tell by looking at the seeds whether or not they are pure strain?

6. Can you tell by looking at the seeds what features the next generation will have?

Return the seeds to the package.

The seeds in package 2 are the offspring of the seeds in package 1. Open package 2 and empty the contents into the dish.





7. Name at least two features that are similar in all the peas.

8. What would you predict the seeds produced by plants from these seeds would look like?

Return the seeds to the package.

The offspring of the seeds from package 2 are in package 3. Open package 3 and empty the contents into the dish.

9. Name at least two features that are similar in all the peas.

10. What similarities do you notice in the seeds in packages 1, 2, and 3?

11. What would you predict the seeds produced by plants grown from the seeds in package 3 would look like?

12. What would you predict the seeds of future generations would look like?

13. Explain the basis of your answer to question 12.

Return the seeds to package 3.

B. AREN'T ALL PEAS ROUND?

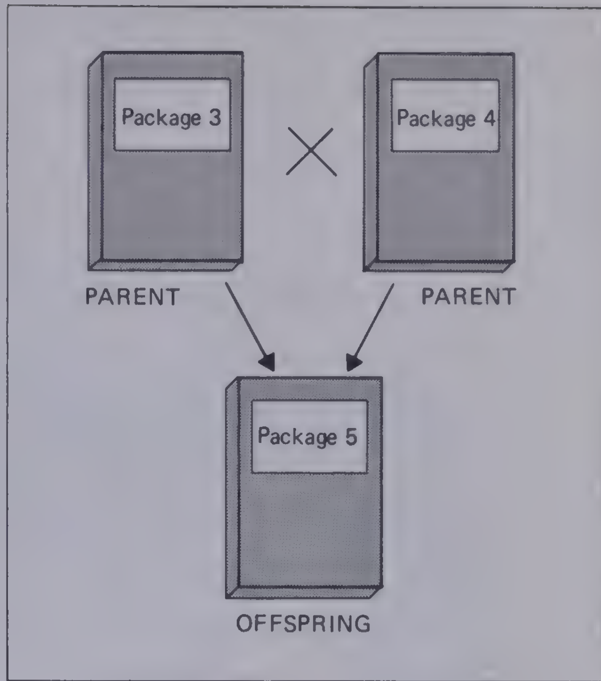
The next package, 4, contains seeds from a different family of peas. That is, they are not related to the seeds in packages 1, 2, and 3. Open package 4 and empty the contents into the dish.

14. Name at least two features that are similar in all the peas.

All the seeds in the preceding generations of this family looked like these seeds.

15. What do you predict the next generation will look like?

16. Why did you make this prediction?



17. How do the seeds from package 4 differ from the seeds in packages 1, 2, and 3?

Return the seeds to package 4.

At this point, you may want to review the pattern of inheritance in beans as you observed them in the last investigation.

A plant from the seeds in package 3 was crossed with a plant from the seeds in package 4.

Stop! Make a prediction first.

18. What kind of seed texture would you predict would occur from a mating of plants grown from seeds in packages 3 and 4?

Open package 5 and empty the contents into the dish.

19. Describe the texture of the seeds.

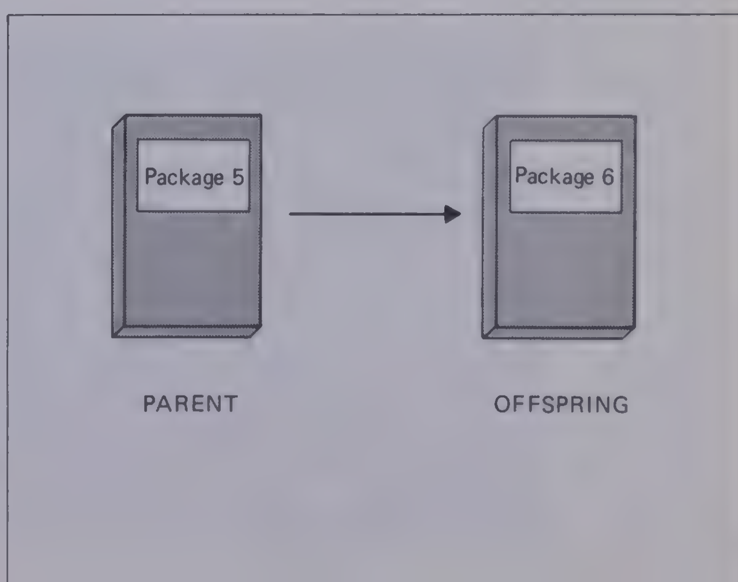
20. Which parent or parents do the seeds resemble?

Return the seeds to package 5.

The seeds in package 6 are the offspring of the seeds in package 5. Stop. Do not open package 6 yet.

21. Before opening package 6, predict the texture of the seeds in the package.

22. Explain why you made this prediction.



Open package 6 and empty the contents into the dish.

23. Describe the texture of the seeds.

24. Did you predict correctly or incorrectly?

Return the seeds to package 6 and close it.

25. What do you predict the ratio of seed textures in package 6 to be?

Reopen package 6 and count the number of each kind of seed texture.

26. Enter the number and kind of each seed texture.

27. What is the ratio of the seed textures?

28. How does the actual ratio of seed textures agree with the ratio you predicted in question 25?

29. Is there any similarity between the patterns of inheritance of the peas and the beans? If you answered "yes," explain the similarity in the patterns.

C. AND NOW, BACK TO THE PEA PATCH

The evidence you have gathered thus far points to a similar pattern of inheritance in both beans and peas. You can see this pattern again by completing Diagram 1 on your data sheet.

30. What kind of offspring do pure strain parents produce?

31. What kind of offspring will result from a crossing of two different pure strain parents?

32. If you cross the offspring that result from a cross of two different pure strains, what will the offspring look like?

33. Therefore, is the inheritance of features something you can or cannot predict? Explain.

CONCEPT SUMMARY.

Investigation 7

Will Your Prediction Go Up in Smoke?

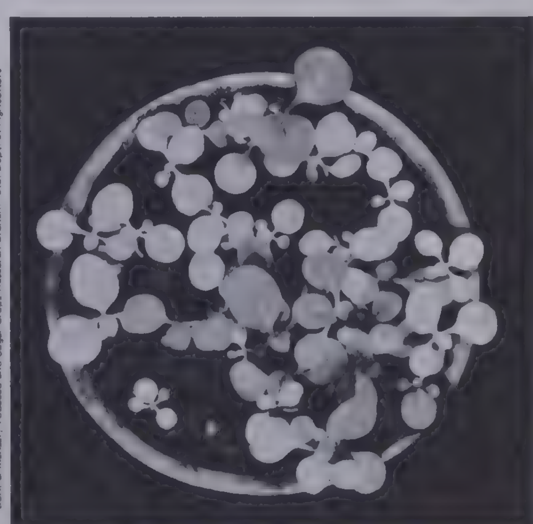
Even Computers Have Trouble With Ratio

The passing on of features from generation to generation seems to follow a regular pattern. You discovered this from your observations of the beans and peas. Does this pattern hold true for other forms of life too—like tobacco plants, for instance?

You will be given three Petri dishes. These dishes contain tobacco seeds which have just germinated. When the seeds were put into the dishes about ten days ago, dish 1 was left in the light. Dishes 2 and 3 were placed in the dark.

Count the number of green plants and the number of albino (yellow) plants in each dish. Be sure to count the number of plants, not leaves. Find the ratio of green plants to yellow plants in each dish. Record this information after day 1 in Table 1 of your data sheet.

On the second day, be sure you get the same three dishes back. Count the color of the plants in each dish. Find the ratio and record the data after day 2 in Table 1.



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1. If the conditions remain the same, what do you predict would be the color(s) of the plants in dish 1 on day 3?

2. If the conditions remain the same, what do you predict would be the color(s) of the plants in dish 2 on day 3?

3. If dish 3 were transferred to the light, what do you predict would be the color(s) of the plants on day 3?

4. Explain the prediction you made in question 3.

Be sure you get the same three dishes again on the third day. Dish 3 was transferred to the light. This change of condition is noted in Table 1. Count the color of the plants in each dish again. Calculate the ratio and record the data after day 3 in Table 1.

5. How do the results in dish 3 compare with the prediction you made in question 3?

6. Explain why you would like to keep or change your prediction.

Count the color of the plants in each dish again on the fourth day. Calculate the ratio and record the data after day 4 in Table 1. Repeat this procedure on the fifth day and record the data after day 5 in Table 1.

7. How do the results in dish 3 compare with the prediction you made in questions 3 or 6?

8. Using the word "pattern," explain your prediction.

9. How would you explain the final results in dishes 1 and 3?

10. What do you think caused the final result in dish 2?

11. If you were to put dish 2 in the light for two or more days, what do you predict would happen?

12. If you were to put dish 1 in the dark for two or more days, what do you predict would happen?

13. Explain the predictions you made in questions 11 and 12.

14. What seems to be influencing the results of the three dishes?

A. HAVEN'T WE MET BEFORE?

There are many who believe that all a scientist does is do experiments. This is an incorrect belief. Science is a way of thinking. Scientists make predictions. They test their predictions, collect data, and draw conclusions based on their data. This is what you have been doing, especially in the questions you have been answering.

With this thought in mind, think about these questions:

15. What was the ratio of the two colors in dishes 1 and 3 on the final day?

16. Where have you seen this ratio before?

17. Compared to previous observations, what generation do you think these tobacco plants represent?

18. What do you think the parents of these tobacco plants looked like?

19. What do you think the grandparents of these tobacco plants looked like?

Summarize the results of the last three investigations by describing the features of each generation in Table 2.

If you know the pattern of inheritance, you can trace the history and predict the future of a feature. This is what you just did in Table 2. However, does a feature always turn out as predicted?

B. CAN YOU BREAK A PATTERN?

You have learned to recognize a pattern. There can be a pattern of inheritance, for instance. You can make predictions if you know the pattern. However, is a pattern ever broken?

20. What color were the plants in dish 3 during the first two days?

21. What color were the plants in dish 3 during the last 2-3 days?

22. What do you think caused the difference?

Diane Koos from Black Star

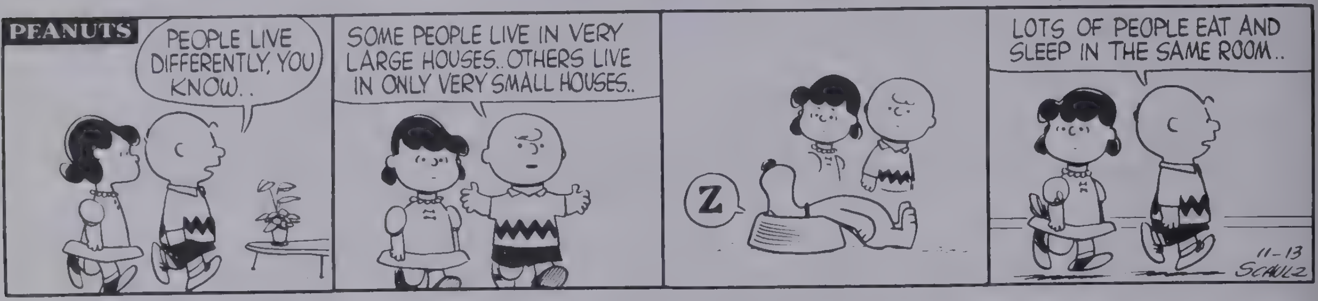
23. In other words, what could affect an inherited feature?

Here are two individuals.

Danny Lyon © 1968 Magnum Photos

Bruce Roberts from Rapho-Guillumette

© 1957 United Feature Syndicate, Inc.



St. Louis Post Dispatch from Black Star

Both were born with the same general features. One had the comforts of home, loving parents, good food, and a sound education.

The other fought the rats and cockroaches in a slum dwelling, had only one parent in the home, had an inadequate diet, and went to a poor school.

24. Are they both as likely to grow up to their full potentials? Explain your answer.

25. Again, what could affect an inherited feature?

CONCEPT SUMMARY.

Investigation 8

What's a Clear Chip Worth?

Questions, questions, questions. This is the fun of science, asking questions and seeking answers. But the real reward comes when answers can be supported by experimental data.

When was the last time you asked someone to prove his statements?

Here are some of the answers you have found so far:

a. Life comes from previous life.

b. A population can reproduce rapidly.

c. Some organisms reproduce by dividing, a method involving only one parent.

d. In sexual reproduction, two sex cells are involved, and the offspring do not look exactly like the parents.

e. A pattern of inheritance can be observed over a period of generations.

f. The pattern of inheritance can be predicted.

g. The appearance of inherited features can be affected by the environment.

From your observations of the bean, pea, and tobacco plants, you also learned that:

a. Each parent has definite features. A feature may be brown color, rough skin, or green leaves.

b. When two pure features are crossed, only one feature usually appears in the first generation. For instance, all the beans of the first generation were brown. The other feature disappeared.

c. When the offspring of the first generation were mated to each other, the missing feature reappeared. For instance, the rough texture reappeared in the peas of the second generation.

d. The features in the second generation appeared in a definite ratio. In the case of the tobacco plants, there were about three green to every one albino.

Therefore, as a result of what you have observed in the peas, beans, and tobacco plants in the last three investigations, some puzzling questions have been raised:

a. What does a parent pass on to the offspring that influences the development of a feature?

b. Are all features passed on equally to the offspring?

c. How is it possible for one feature to disappear from parent to offspring? Note the results of your first generation bean, pea, and tobacco plants.

d. How is it possible for a missing feature to suddenly reappear? Note the results of your second generation.

e. Why do some features appear more often than others? Note the ratio of your second generation.

You have seen a pattern repeated three different times in the bean, pea, and tobacco plants. Perhaps this same pattern holds true for other plants and animals, too.

What is the cause of this pattern? How can we explain this pattern?

When a scientist tries to explain something he can't see, he develops a *model.* A model is not the real thing. A model is used to represent the real thing.

Judy Johnson models clothes. But you must imagine what the clothes might look like on you.

Ronald Harrison builds models of rockets. From information that describes rockets, Ronald can build models to represent the real thing.

Max Tharpe from Monkmeyer

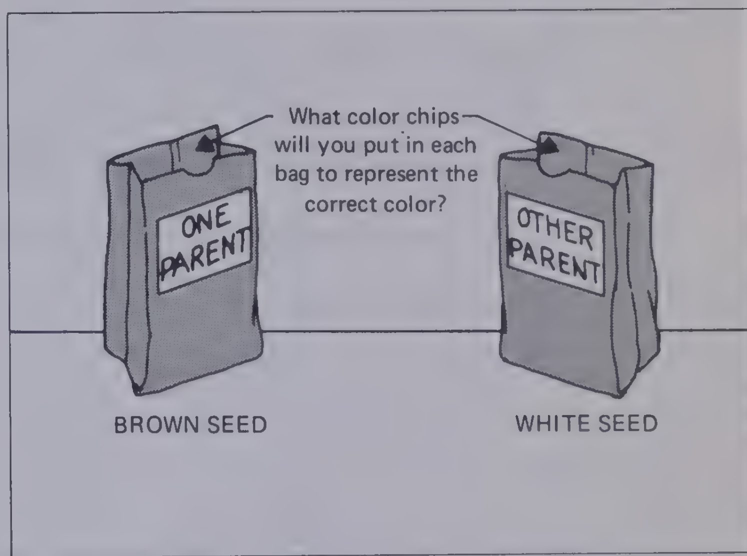
Without realizing it, you have already built a number of models in this class. When you shook and listened to the box, you were trying to develop a mental explanation of what was inside. You could not see inside, but you could construct a mental model.

Thus, what kind of a model—a mental explanation—can be built to explain the pattern of inheritance we have been observing?

A. A "BIT OF INFORMATION"

As you have learned, a scientist often begins the solving of a problem by making a prediction or two. Can we predict that something is passed from parent to offspring? Let's imagine that this is true and call this something a "bit of information."

We must now test the prediction. Poker chips will represent the "bits of information." You will be given two empty bags, and some brown chips and clear chips.



To start, let's have one bag represent one parent and the other bag represent the other parent. Each bag will hold the "bits of information" present in one parent. Now let's work out what kind of chips ("bits of information") you will put into each bag.

Let one bag represent one parent from a pure strain of brown bean seeds.

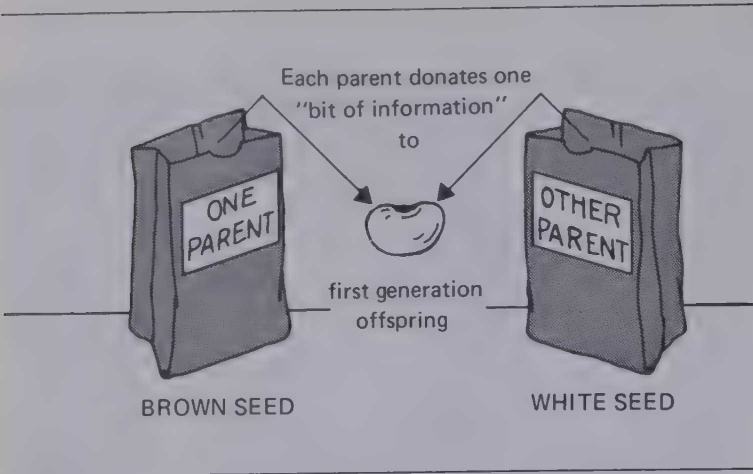
1. What kind of chips will you put into this bag? Why?

Let the other bag represent one parent from a pure strain of white bean seeds.

2. What kind of chips will you put into the other bag? Why?

3. The number of chips you put into these two bags is not important. Why?

We will now have to make another prediction. Let us suppose that each parent donates one "bit of information" to the offspring.



Take out one chip from each bag. What color chips do you have? Record this combination of chips in Table 1, Trial 1, on your data sheet.

Stack the two chips together. Hold the stack up to the light and look through them. Record the overall color that you see in Table 1.

Return the chips to their original bags and shake.

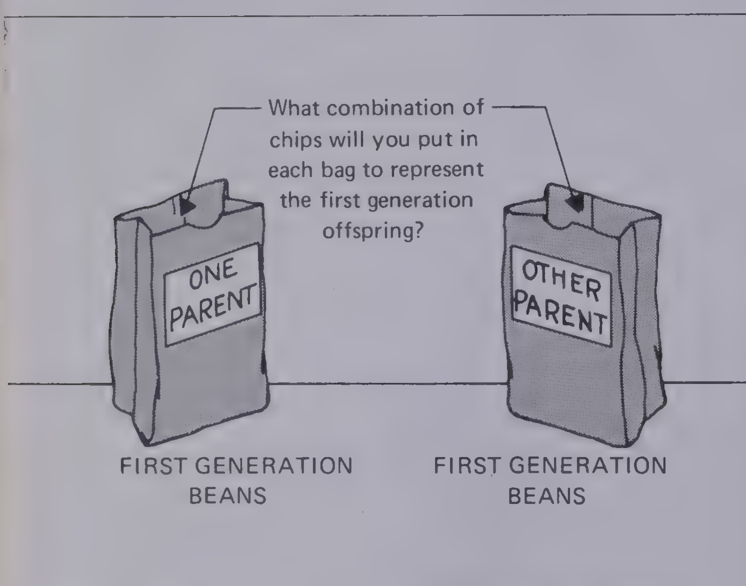
Remove one chip from each bag again. Record this combination of chips in Table 1, Trial 2. Record the overall color also under Trial 2. Return the chips to their original bags and shake.

Continue to repeat this procedure until you know what the first generation beans will look like.

4. How many combinations of chips did you get? What combination(s)?

5. Are there any other combinations possible? Explain.

6. According to your data, what color are the beans in the first generation?



B. WHERE HAVE I SEEN YOU BEFORE?

The model seems to work for the first generation. Will the same procedure work for the second generation?

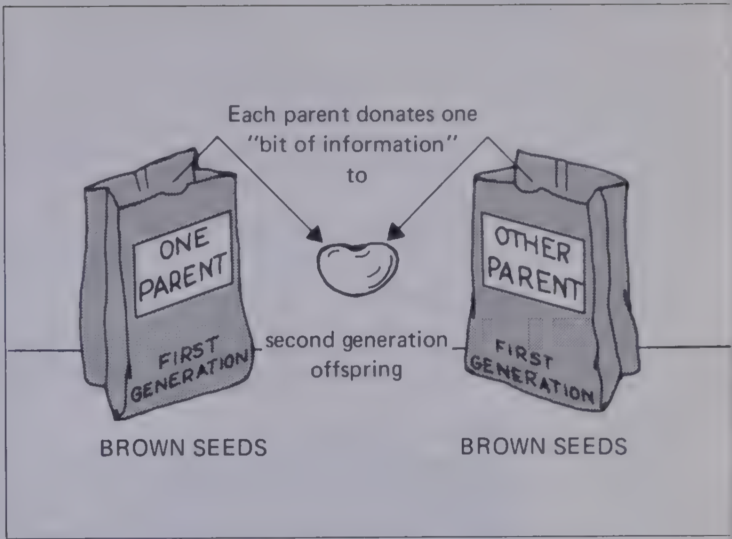
7. What color were the beans in the first generation?

8. What combination of chips represents the color of the offspring in the first generation?

Again, let one bag represent one parent and the other bag the other parent. Put the combination of chips necessary to represent one parent in one bag. Repeat this combination until half of the chips are used.

Put the combination of chips necessary to represent the other parent in the other bag. Repeat this combination with the other half of the chips given to you.

The two bags now represent the first generation offspring. You are going to cross the first generation offspring with each other. Remember, we predicted that *each parent donates one "bit of information" to the offspring.*



Take out one chip from each bag. What two color chips do you have? Record this combination of chips in Table 2.

Stack the two chips together. Hold the stack up to the light and look through them. Record the overall color that you see in Table 2.

Return the chips to their *original* bags and shake.

Remove one chip from each bag again. Record this combination of chips and the color it represents in Table 2. Return the chips to their original bags and shake. Repeat this procedure at least 15 more times.

Obtain the totals from three other classmates for Table 2. Add up the grand total. Determine the overall color of each of the three columns.

Calculate the ratio. Remember that you do this by dividing each of the three numbers by the smallest number.

9. What is the overall ratio of the two colors in the second generation?

10. Where have you seen this ratio before?

C. IS THIS THE MODEL?

Remember, a model is something a scientist makes to represent something else. It's like daydreaming, only you have everything figured out in your mind.

That's all we have been doing in this investigation. We've been trying to figure out why we keep getting the same type of offspring or ratios with different kinds of plants.

We have built a model that says:

11. A feature is represented by a ___?___

12. One "bit of information" is passed from ___?___

13. Each offspring receives one "bit of information" for each feature from ___?___

In conclusion,

14. How much information must an offspring receive for each feature from the parents?

CONCEPT SUMMARY.

Investigation 9

It's a Dog's Life

"My name is Spad. I hope you don't confuse me with that imposter beagle who happens to bear a slight resemblance. He's just an actor in a comic strip. It's strictly a Peanuts operation."

Hal Lowe Globe Photos

"If you don't like my outfit, don't blame me. Some crazy human with a warped sense of humor put it on me."

"If you don't like my looks, I can't help that either. I inherited my looks from my parents. It's a dog's life. How did I come to look like this? It's those 'bits of information.' What are they anyway?"

In the last investigation, you made a model which said:

a. A feature is represented by a "bit of information." For instance, eye color, seed shape, or hair texture are controlled by a "bit of information."

b. "Bits of information" are passed from parent to offspring.

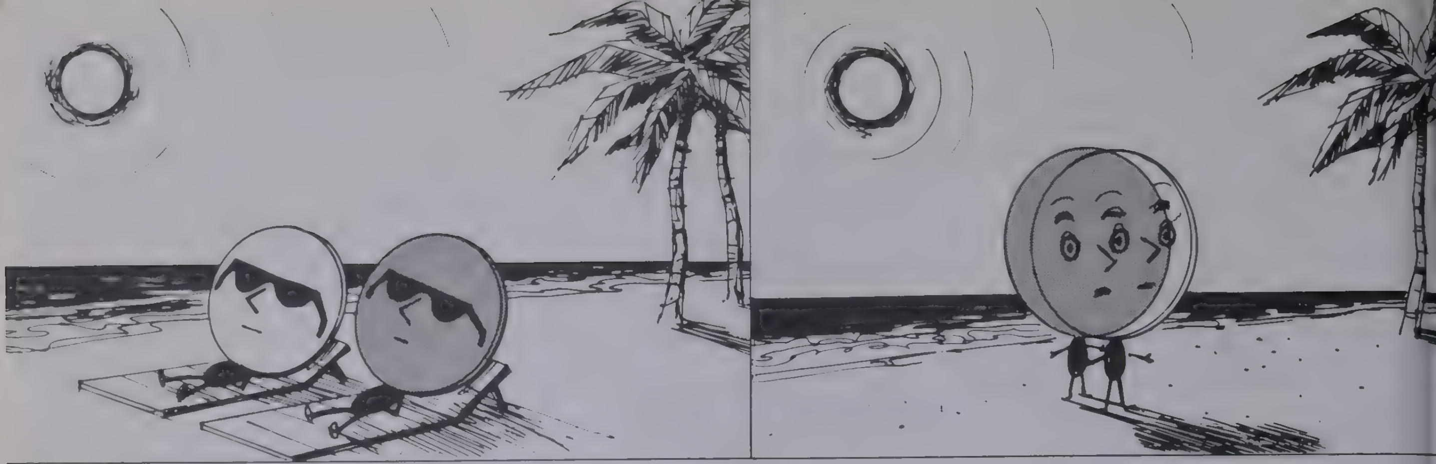
c. Offspring receive one "bit of information" for every feature from each parent.

But what are these "bits of information"? How do these "bits of information" work?

A. WHAT'S MY MODEL LIKE?

Let's review your model first.

1. How many chips does each parent pass on to an offspring for each feature?



2. How many chips do you need to represent one feature in an offspring?

3. What does a chip represent?

Now let's talk in terms of "bits of information" instead of chips.

4. How many "bits of information" does each living thing have for each feature?

5. How many of these "bits of information" are passed on by *each* parent to the offspring?

What happens if the "bits of information" are not the same?

6. Pick up two brown chips. Stack them together and hold them up to the light. What overall color do you see?

7. Pick up two clear chips. Stack them together and hold them up to the light. What overall color do you see?

8. Pick up one brown and one clear chip. Stack them together and hold them up to the light. What overall color do you see?

As you can see, although two "bits" are present, the feature you see may be controlled by one "bit." This is because one "bit" may hide the other "bit." The result is a *dominant* feature. The other "bit" that is hidden is called the *recessive* feature. The "bit" that is hidden is still present and may produce its feature in a later generation. To be sure you understand this concept, let's see if you can apply it to your past observations.

B. BACK TO THE BEANS

Let's start with the beans. If necessary, refer to Investigation 5.

9. How many "bits of information" for color does each bean seed have?

10. What "bits of information" for seed color does the pure strain brown parent have?

11. What "bits of information" for seed color does the pure strain white parent have?

12. What "bits of information" does each bean in the first generation have?

13. If white is present in the first generation beans, why don't you see it?

14. In the first generation, which is the dominant "bit"?

15. In the first generation, which is the recessive "bit"?

16. If you could not see the white "bit" in the first generation, how do you know it was present?

17. How many combinations of "bits" are present in all the second generation bean seeds?

18. What combinations of "bits" can you have in a brown bean?

19. Did the white feature appear in the second generation?

20. How many and what kind of "bits" must be present in a white bean seed?

In the model you have developed, a brown bean seed is represented by a brown chip and a white bean seed by a clear chip.

The color in the first crop can be explained by assuming that the clear chip is hidden by the brown chip. In other words, the "bit of information" for brown color in beans is *dominant.*

On the other hand, a *recessive* feature can be seen when there is no dominant "bit of information" present. That is, a recessive feature is observed when both "bits of information" are recessive.

Smooth Peas

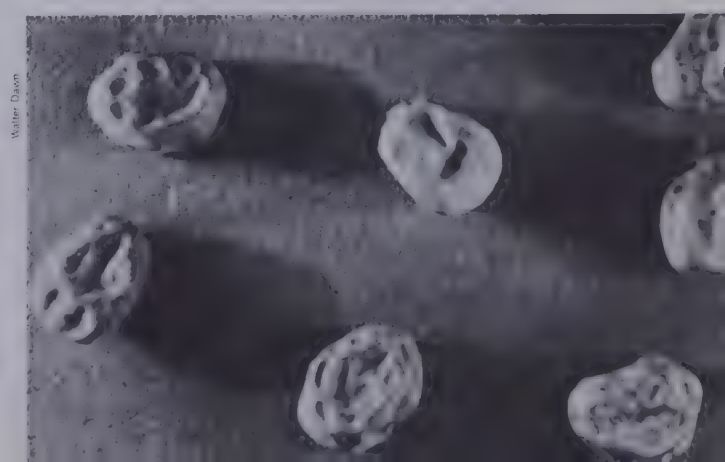
C. BACK TO THE PEAS, TOO

Let's now consider the pea family. Can the same concept of dominance and recessiveness be applied here too? Refer to Investigation 6.

21. What were the appearances of the two parents in packages 3 and 4?

22. What "bit of information" did each of these peas pass on?

Wrinkled Peas



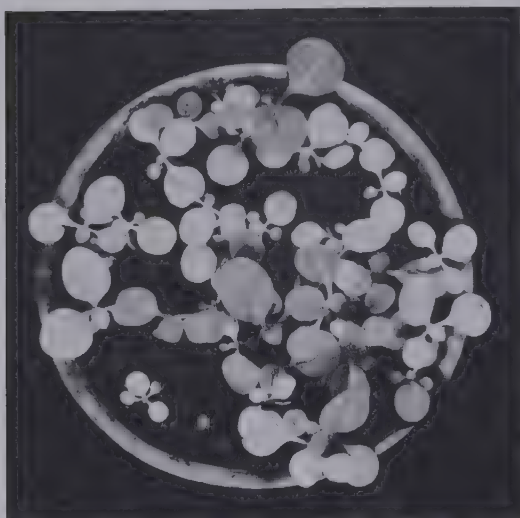
23. Explain why all the seeds in package 5 appeared smooth.

24. What ratio of seed textures did you observe in package 6?

25. What combination of "bits" can you have in a smooth seed in the second generation?

26. How can two possible combinations of "bits" for texture give smooth seeds?

It seems that the model works just as well for peas as it did for beans. In both cases the model showed a 3:1 ratio in the second generation. You might ask, "Will I always get a ratio of 3:1 in the second generation?" Or, "Why do I always get a 3:1 ratio?"



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D. BACK TO THE TOBACCO PLANTATION

In this family you only saw the second generation. When you counted the tobacco plants, you observed a ratio of about three green plants to one albino plant.

Let's see if you can use the model based upon your experience with beans and peas. You are going to make a prediction about the first generation from which your tobacco plants came. If necessary, refer to Investigation 7.

27. What was the appearance of the first generation plants?

28. How many "bits" for color did each plant in the first generation have?

29. What were these "bits"?

30. Compare questions 27 and 29. How do you explain the appearance of the plants in the first generation?

31. What "bits of information" do you think each original parent had?

If the model is a good one, it should explain your observations of the beans and peas. It should also allow you to predict what the previous generations were like in the tobacco plants.

One reason you can make these predictions is because you have learned that there are two kinds of "bits of information."

32. What are the two kinds of "bits"?

CONCEPT SUMMARY.

Investigation 10

It Takes Brains To Gamble

You have been developing a model to explain why a pattern of inheritance occurs.

Your model shows that:

a. "Bits of information" control features.

b. "Bits of information" are passed from parents to offspring.

c. Each parent and each offspring contain *two* "bits of information" for each feature.

d. Each parent passes either *one* of its two "bits of information" to each offspring.

e. If the two "bits of information" obtained from both parents are the *same*, then the offspring has the feature.

f. If the two "bits of information" from both parents are *different*, one "bit of information" may be seen and the other "bit" may be hidden.

This may be a nice, neat model and the explanation seems to make sense, but: Why does it work? How does it work? What is this "bit"?

A. WHY DOES IT WORK?

Why do we keep getting a 3:1 ratio in the second generation?

Perhaps your results can be explained by trying this simple experiment.

Use two coins of your own which are the same denomination (pennies, nickels, dimes, or quarters). Flip both coins at the same time. If you are working in pairs, each of you can flip a coin at the same time. What are the possible combinations you can get? Record these in Table 1.

What combination do you have? Record this in Table 1 by making a tally mark under the correct combination.

Flip both coins again. Did you get the same combination? Record this in Table 1 by making a tally mark under the appropriate combination.

Continue this procedure at least 60 times. Total up each column of tally marks.

Determine the ratio by dividing each total number by the smallest total number.

1. How often did two heads show up? Can you explain why?

2. How often did two tails show up? Can you explain why?

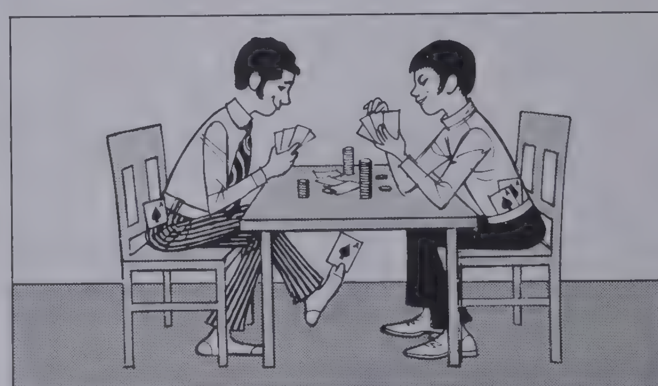
3. How often did a heads-tails show up? Can you explain why?

Hold both coins again. Before you flip:

4. Would you take an even bet that two heads would show up? Why?

Don't bother flipping to find out. If you took that bet, stay out of all "coin match" games the rest of your life. You'll be taken to the "cleaners" every time.

Sybil Shelton from Monkmeyer



Do You Know What the Chances or Odds Are?

What Are the Odds for This Dropout Succeeding in Life?

5. What are the chances of two heads showing up?

And this is where we come to a key word, *chance*. Reread question 5. Note the word "chance." As it is used, chance does not mean you do not know what is going to happen. You do know what is most or least likely to happen! You can predict the odds, right? Then you know very well what the chances are.

6. What are the chances for pulling an ace of spades out of a deck of cards?

7. What are the odds for pulling a heart out of a deck of cards?

B. DOES IT WORK WITH PEOPLE, TOO?

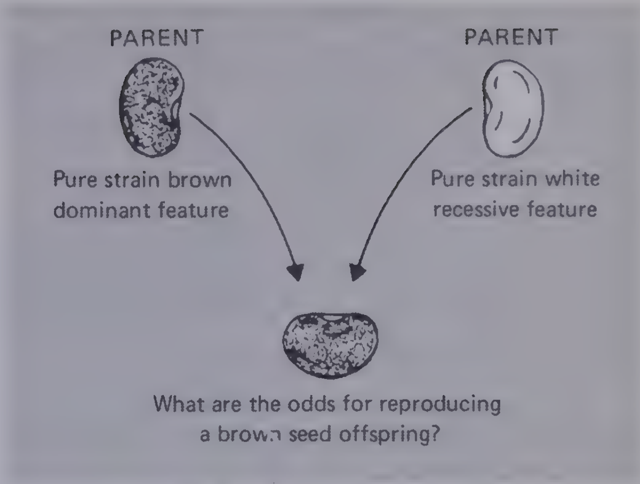
Just once more with the beans. What are the odds in these situations?

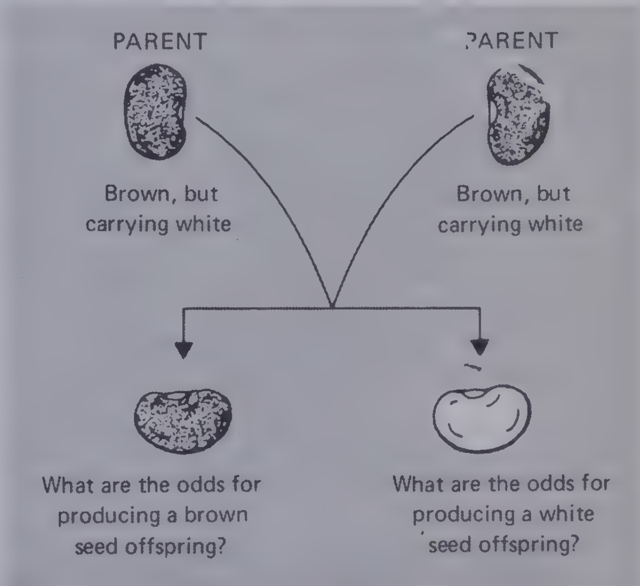
8. One bean parent is a pure strain for brown seed color. It is the dominant feature. The other bean parent is a pure strain for white seed color. It is the recessive feature. What are the odds of these parents producing brown seed offspring? Explain.

9. Both bean parents are brown seed in color. But both are carrying a recessive feature for white seed color. What are the odds of these parents producing brown seed offspring? White seed offspring? Explain.

Let's try some situations with people.

10. Imagine that both parents are brown-eyed. Brown eyes are a dominant feature. Both are also carrying a recessive feature for blue eyes. What are the odds of this couple having a brown-eyed baby? Blue-eyed baby? Explain.





Carl Di Lisio is the Building Commissioner for the city of Yonkers, New York. His grandparents came from Italy.

Carl's wife, Kathleen, has an Irish ancestry.

11. Kathleen is blue-eyed. We know that blue eyes are a recessive feature. We also know that there must be two "bits of information" for every feature. Therefore, what "bits of information" for eye color does Kathleen have?

12. Carl is brown-eyed. We know that brown eyes are a dominant feature. What "bits of information" for eye color does Carl have? Is that the only combination possible?

Kathleen and Carl have three children—Susan, Diane, and Michael. Susan and Michael have brown eyes; Diane has blue eyes.

13. Are any of the children pure strain brown-eyed? Explain.

14. How was it possible for the Di Lisios to have a blue-eyed baby? Explain.

C. UGH, IT TASTES AWFUL

You have many obvious features: hair color, number of fingers, complexion, and sex.

However, you also have some not so obvious traits which you inherited from your parents. For instance, can you roll your tongue into the shape of a "U"? About 70% of the population can roll their tongues that way.

15. What percentage of students in your class can roll their tongues like that?

Between 7.5% to 10% of the people are left-handed. Being left-handed is a normal, inherited feature.

16. What percentage of the students in your class are left-handed?

Some people can taste a harmless chemical called PTC. Others cannot. Obtain a piece of PTC paper from your teacher and chew it.

17. 70% of the whites, 90% of the blacks, and 90% of the Orientals can taste PTC. What percentage in your class can taste PTC?

There are many other inherited features, such as wavy hair, crooked little finger, widow's peak, freckles, and dimples.

Jim Cron from Monkmeyer

Max Tharpe from Monkmeyer

Stan Wayman from Rapho-Guillumette

Compare the percentages in your answers to questions 15-17 with the national averages.

18. If the class percentages are close to the national percentages, how does this tell you that the feature is inherited? Hint: Remember about being able to predict odds.

D. ¡EL SAVOR ES HORRIBLE!

Three generations of a family are shown in Diagram 1 on your data sheet. Each person's ability or inability to taste PTC is also given. The ability to taste PTC is a dominant feature, while the inability to taste PTC is recessive.

19. How many "bits of information" for the ability to taste PTC should each individual in Diagram 1 on your data sheet have?

20. How many kinds of "bits of information" does a nontaster have?

21. How many recessive "bits of information" does each nontaster have?

22. List all the people with the recessive feature.

Find each person listed in question 22 in Diagram 1. Place the small letter "t" to represent nontasting in the appropriate circle(s). Each circle represents one "bit of information."

23. Could any of the nontasters have a "bit of information" for tasting? Explain.

24. What "bit of information" did Grandfather Lopez pass on to Father Lopez?

25. What "bit of information" did Grandmother Lopez pass on to Father Lopez?

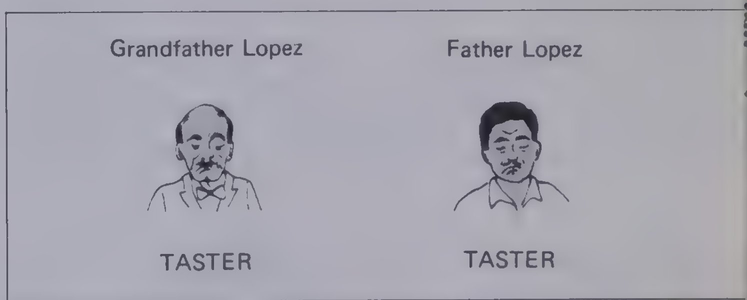
26. What "bits of information" does Father Lopez have?

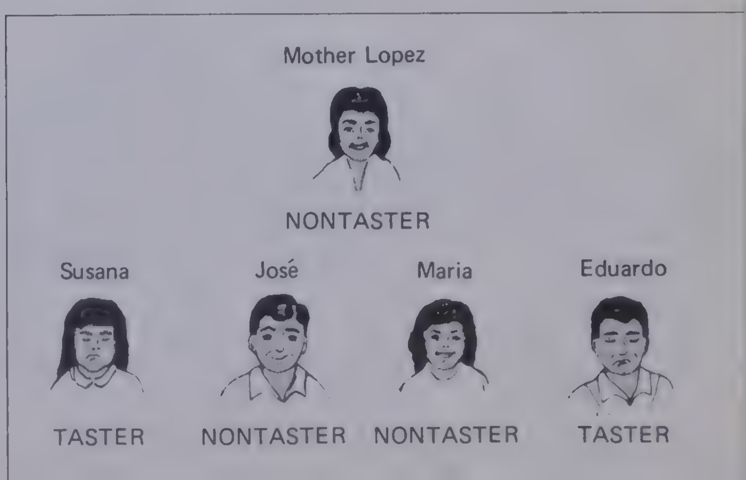
If Father Lopez has a "bit of information" for taste, place the capital letter "T" in one of his circles.

27. Are Father Lopez's two "bits of information" the same or are they different?

28. What "bit of information" did Mother Lopez give to her four children?

Enter the symbol for this "bit of information" in one of the circles for each child.





29. What "bit of information" did Susana and Eduardo receive from their father?

30. What "bit of information" did Father Lopez contribute to José and Maria?

Add the appropriate symbol to the remaining circles for each of the children.

You know one "bit of information" Grandfather Lopez has because it was passed on to Father Lopez. Add this symbol to one of the circles.

31. If you were told Father Lopez's sister was a nontaster, could you now tell what other "bit of information" Grandfather Lopez had? Explain.

32. If the Lopez's were to have a fifth child, what are the odds for having a taster? Nontaster? Explain.

You can answer the above question because you have learned that the pattern of inheritance is predictable. The reason it is predictable is because you know what may happen to each "bit of information."

33. That is, you can predict the features an offspring will inherit because you can figure out the ___?___

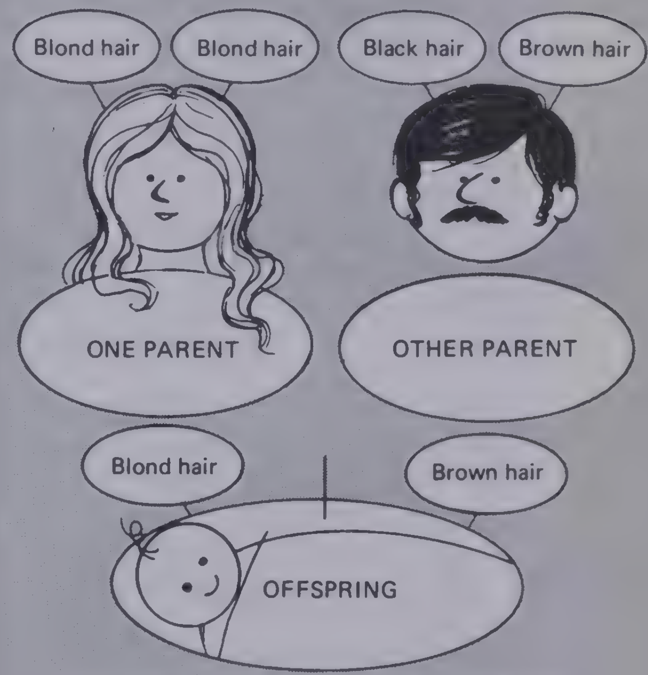
CONCEPT SUMMARY.

Investigation 11

Wrinkled Peas for Dinner?

You have been constructing a model to explain a pattern of inheritance. Your model shows you that a parent has two "bits of information" for a feature and only one of these "bits" can be passed on to a single offspring. Which "bit" is passed on is determined by chance. The other parent contributes the other "bit" for that feature. In this way, an offspring has the same number of "bits of information" for a feature as each of its parents. It is these "bits" which determine the appearance of the offspring.

Each parent has two "bits of information"



Each parent contributes one "bit" to an offspring

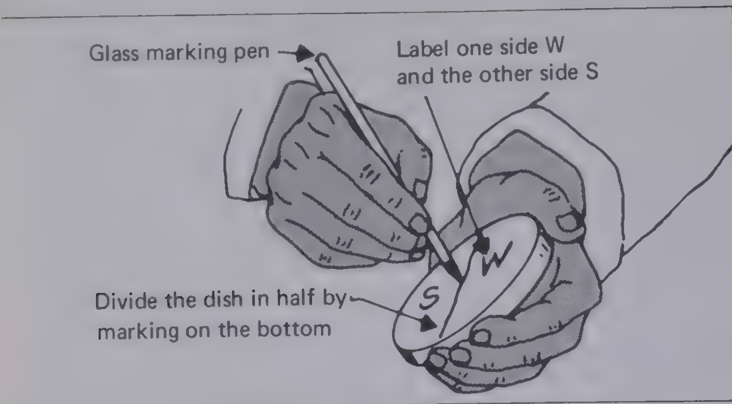
But what is a "bit of information"? Where is the "bit of information" found?

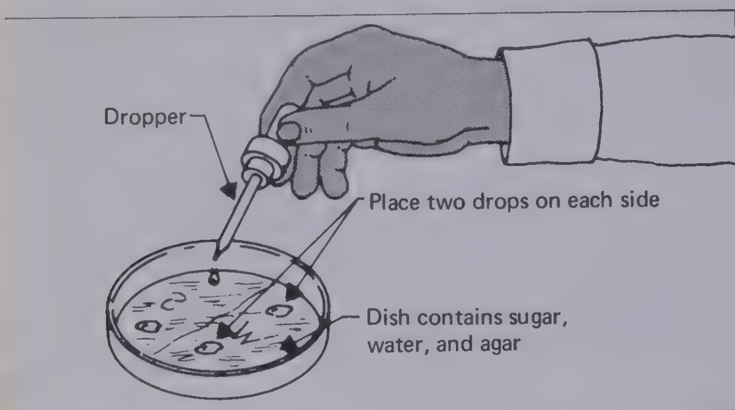
A. WHAT DOES A WRINKLED PEA TASTE LIKE?

You will remember having seen two kinds of peas in your previous investigations. One kind had smooth skins and the other had wrinkled skins. Have you ever wondered why the peas that come in cans and frozen food packages are smooth and not wrinkled? Is it because the smooth ones look nicer? Or is there another reason?

You will be given a sterile Petri dish. Do not open it until you are ready to do the experiment. It contains sugar, water, and agar.

With a marking pen, draw a line dividing the bottom of the dish into two halves. Label one side "S" for smooth and the other side "W" for wrinkled. See drawing at top of next page.





You will also be given 2 dropper bottles. The one labeled "S" contains smooth peas that have been finely ground. The bottle labeled "W" contains wrinkled peas that have been finely ground.

Place 2 drops of the liquid from bottle S on the side of the dish labeled "S." Do not put the drops together. Keep them separate. Place 2 drops of the liquid from bottle W on the side of the dish labeled "W." Keep the drops separate.

After 30 minutes, blot up the 4 drops of liquid. Place one drop of iodine solution on each of the four spots where the drops were. Wait 30 seconds. Then blot up all the iodine.

HANDLE THE IODINE CAREFULLY.

IT CAN STAIN YOUR CLOTHING.

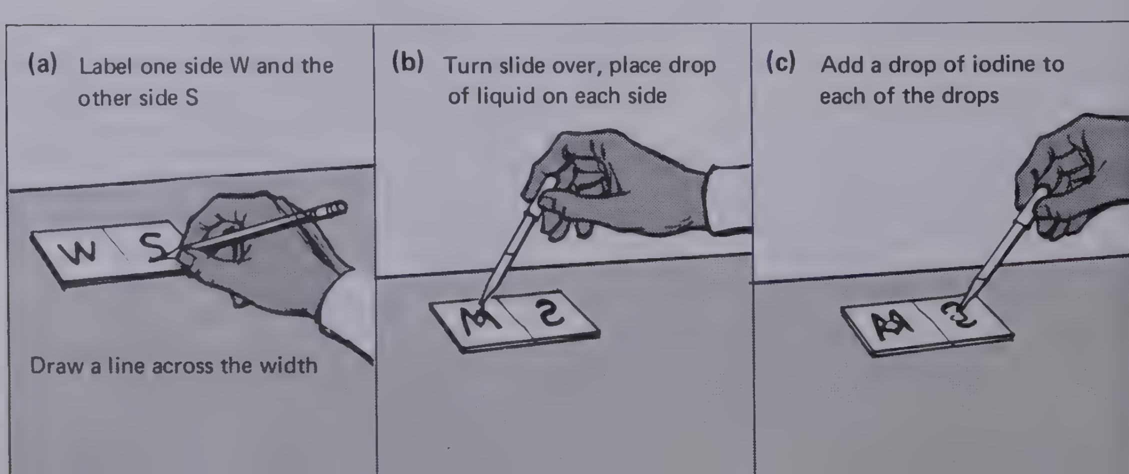
Iodine is used to test for the presence of starch. A blue-black color tells you that starch is present. If you put iodine on cornstarch, a piece of bread, or a potato, it will turn blue-black. If you put iodine on something that does not contain starch, like granulated sugar or a piece of meat, it will not turn blue-black.

1. Which spots turned blue-black?

2. Which spots showed the presence of starch?

3. There are two possible places the starch could have come from. What are they?

With a marking pen, draw a line across the width of a microscope slide. Label one side "S" and the other side "W." Turn the slide over and place a drop of the liquid from the bottle S over the letter S. Do likewise with the liquid from bottle W.



Add a drop of iodine to each of the drops.

4. Which drops show the presence of starch?

5. Other than the agar and water, what else was in the Petri dish?

6. Reread your answer to question 3. In light of your results described in question 4, where do you think the starch came from now? Why?

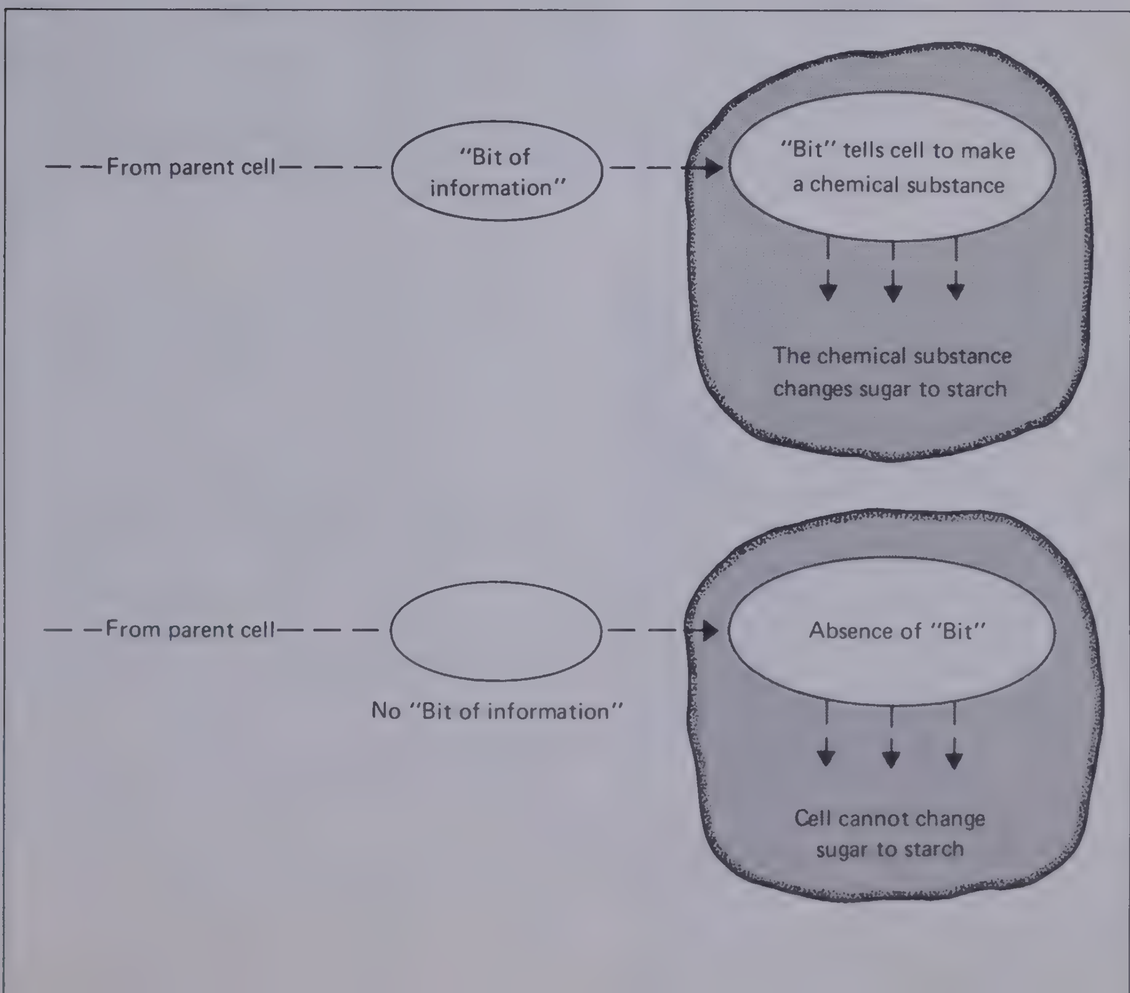
7. What do you think caused the starch to appear?

8. What "bit of information" do you think is in the wrinkled seed?

9. What "bit of information" do you think is in the smooth seed?

B. THEY CALL ME A "GENE"

Now you have actually seen a "bit of information" in action. Something was in one type of pea that caused the sugar to change to starch. That "something" must have been a chemical substance that passed into the sugar. Your results showed you that one type of pea had the chemical substance and the other did not. That is, one kind of pea had a chemical substance that could turn sugar into starch and the other pea did not.



How could one group of peas make the chemical substance? A seed inherits many "bits of information" from its parents. These "bits" are like messengers. The individual cells in the seed then follow the messages. One of the "bits" may "tell" a cell to make a chemical substance that changes sugar to starch.

To summarize:

10. What "bit" did the wrinkled seeds inherit?

11. What "bit" did the smooth seeds inherit?

12. What message did the "bit" give to the wrinkled seeds?

13. What message did the "bit" give to the smooth seeds?

14. Why would you serve smooth peas rather than wrinkled peas for dinner?

15. Therefore, what directs a cell and "tells" it what to do?

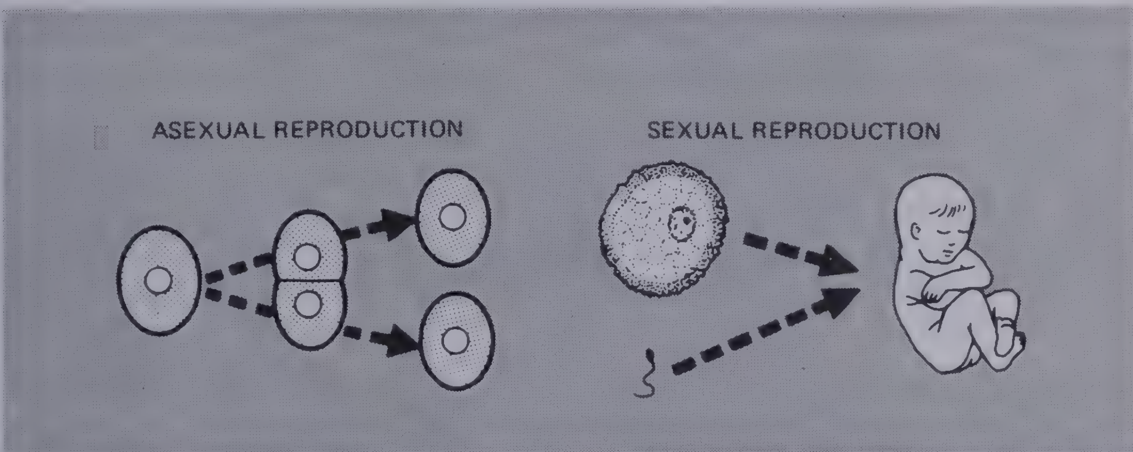
CONCEPT SUMMARY.

Investigation 12

I Am the Secret of Life

You've come a long way—and you've done very well. After this investigation, you will have completed another Idea. Let's review what you have learned so far.

You have learned that living things can reproduce in two ways, asexually and sexually. You have also learned that the inherited features of offspring can often be predicted. You can even predict the odds.



The reason you can determine the odds is because a pattern of inheritance over a period of generations may have already been observed. You may then know what to expect.

In addition, you may have a mental model of what happens when parents pass on their features to their offspring. Your model tells you that:

a. Each offspring is made up of many features.

b. These features are determined by "bits of information."

c. The "bits of information" are passed from parent to offspring.

d. Each parent and each offspring contain *two* "bits of information" for each feature.

e. Each parent passes either *one* of its two "bits of information" to each of the offspring.

f. If the two "bits of information" obtained from both parents are the *same*, then the offspring has that feature.

g. If the two "bits of information" from both parents are *different*, one "bit of information" may be seen and the other "bit" may be hidden.

And if you did the last investigation, you now know how the "bits of information" work. They direct some of the chemical activities in a cell.

But where, in the cell, are the "bits of information" found? What is a "bit of information"?

A. TWENTY-THREE, FORTY-SIX, HIKE!

Your teacher will give you a prepared slide of an onion root tip. Examine it under the microscope. You will remember looking at the same slide in Investigation 3. Compare what you see under the microscope with the figure below. Note the stained materials that stand out in some of the cells.

Onion Root Tip Cells

Courtesy Carolina Biological Supply Co.

In 1888, a scientist gave a name to the deeply colored materials that can be seen when a cell is dividing. He called them *chromosomes* because "chromo" means color and "somes" means bodies.

We now know that almost every cell has chromosomes. These chromosomes can easily be seen when cells divide.

The number, shape, and size of the chromosomes is the same for each individual of a species. For instance, in humans, there are 46 chromosomes in every cell. There are only 8 in every cell of a fruit fly. There is an exception. The sex cells, sperm and egg, have half the usual number. Therefore, when a sperm and egg unite, the normal number is kept in the new offspring.

On the last page of your data sheets there is a picture of the 46 chromosomes from one blood cell. The cell was stained to bring out the chromosomes. A photograph was taken and the picture enlarged. With techniques and photographs of this type, scientists are now able to count, sort, and group chromosomes.

The 46 human chromosomes are present in cells as 23 pairs. Remember, an offspring receives one "bit of information" from each parent. Therefore, one chromosome of a pair comes from each parent.

Cut out all the chromosomes on the last page of your data sheets, and arrange them in matched pairs. Glue a pair of chromosomes in each square of Chart 1 on your data sheet, starting with the largest pair first. The first pair is already shown to help you get a good start.

One other chromosome is also shown. We will call it 23-X. Find 23-Y.

When you finish, compare your chart of chromosomes with the figure below.

1. What major difference do you notice between your chart of chromosomes and the one below?

Human Chromosomes

The sex of an individual can be determined by looking at these charts. If the 23rd pair is matched, XX, the individual is a female. If the 23rd pair is unmatched, XY, the person is a male.

2. If the 23rd pair determines the sex of an individual, what does this tell you about the possible location of the "bits of inheritance"?

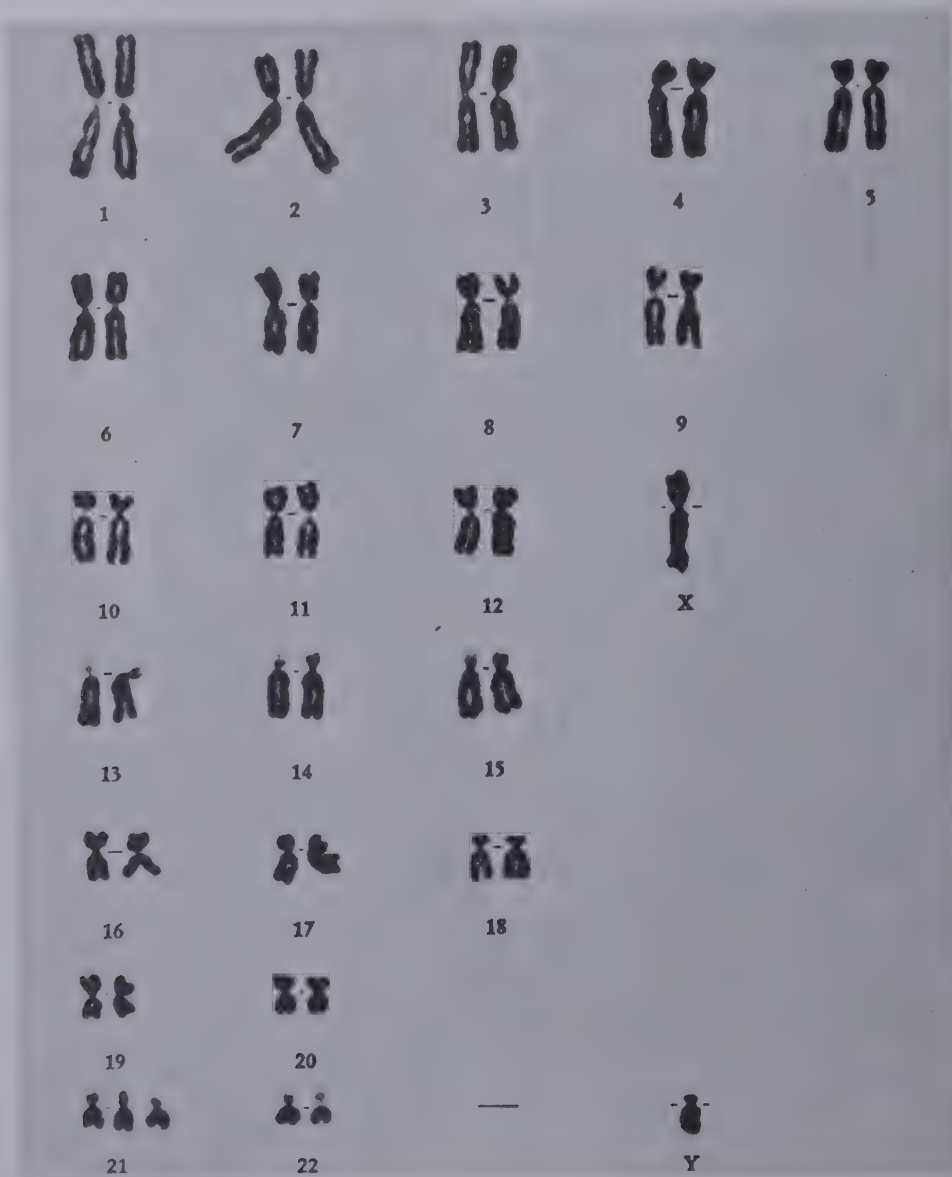
3. What do you think are on the other 22 pairs of chromosomes? Compare the two chromosome charts in part A with the figure below.

B. ONE TOO MANY

You are probably predicting that the "bits of information" are found on chromosomes. At least the features for sex appear to be found on the 23rd pair of chromosomes. What additional proof do we have that the "bits of information" may be found on chromosomes?

Compare the two chromosome charts in part A with the figure below. Look carefully.

Human Chromosomes



4. What major difference do you notice?

People who do not have the correct number of chromosomes suffer from inherited diseases which are incurable.

5. When a person is born an with incorrect number of chromosomes, a disease usually occurs. What does this tell you about chromosomes, "bits of information," and inheritance?

However, not all inherited diseases are caused by an incorrect number of chromosomes. There are people who have the correct number of chromosomes and still have an inherited disease (e.g., diabetes, certain forms of anemia).

6. What do you think the "bits of information" have to do with these diseases? Hint: Look at the concept for Investigation 11.

C. IT HURTS OTHERS, TOO

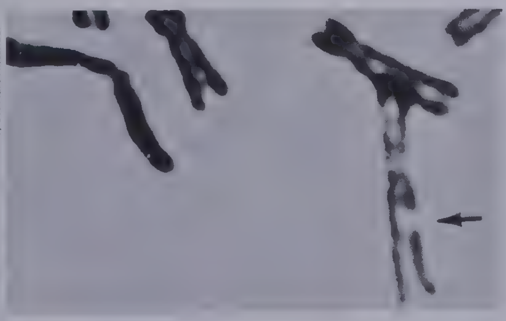
If the "bits of information" are so necessary for the normal functioning of the body, then you can see why scientists are seriously watching a recent discovery.

In March, 1967, Doctors Cohen and Hirschborn of Mount Sinai Hospital in New York reported these findings:

a. Using chromosome pictures of human blood cells, they found that adults who had taken LSD had a greater number of broken or damaged chromosomes than those who did not use LSD.

b. They also found that children whose mothers had taken large amounts of LSD during pregnancy had a greater number of damaged chromosomes than those whose mothers had not taken it.

Mount Sinai School of Medicine, Dr. Kurt Hirschborn



LSD Damaged Chromosomes

The Establishment Is Always Saying LSD Is Harmful. What Do They Know About It?

If LSD does increase the rate of chromosome breakage:

7. What else may be broken on the chromosomes?

8. What do you think may happen to a cell if it has broken chromosomes?

9. What do you think may happen to a baby born with broken chromosomes?

10. In conclusion, what do you think may be carried on the chromosomes?

D. A SOCIAL PROBLEM

By now, you have probably learned that the "bits of information" are carried on the chromosomes. You may have heard of these "bits" referred to as *genes,* which is short for *gene*tic units.

Scientists now know that these "bits" or genes are a chemical substance called *DNA*. They even have a good clue as to how DNA controls a cell's features. Because of DNA, a cell knows what it is to manufacture. For this reason, a muscle cell will always divide and make another muscle cell. Robins will always produce robins and roses will always produce roses.

Discoveries in heredity have raised questions as to further generations. Will it be possible to prevent hereditary diseases by "fixing" the DNA molecule? Will scientists be able to "juggle" the X and Y chromosomes so that parents may choose the sex of their children? Your generation may find the answers.

CONCEPT SUMMARY.

Idea 4
Homeostasis

Investigation 1

Are You Groovy and In Gear?

Some plants respond to sunlight by growing toward it.

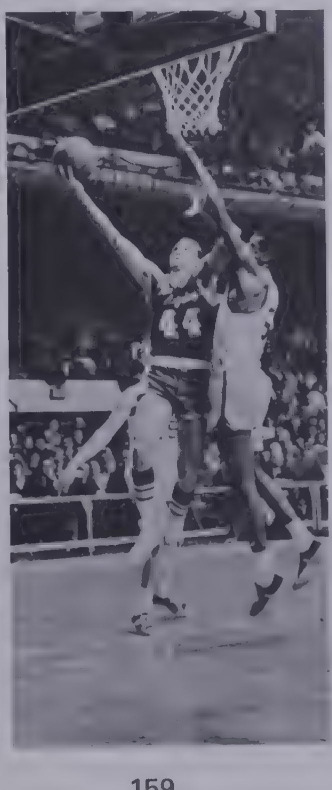
Some people respond to contemporary art.

Athletes respond to every action in a game.

People sometimes respond to other people by falling in love.

What do you think would happen to an organism that could not respond?

Jerry West



Wide World Photos

Peter Max: "The Sixties," 1967

Acrylic on canvas with silkscreen 24" x 24" Courtesy William Zierler, Inc

What Is Love?

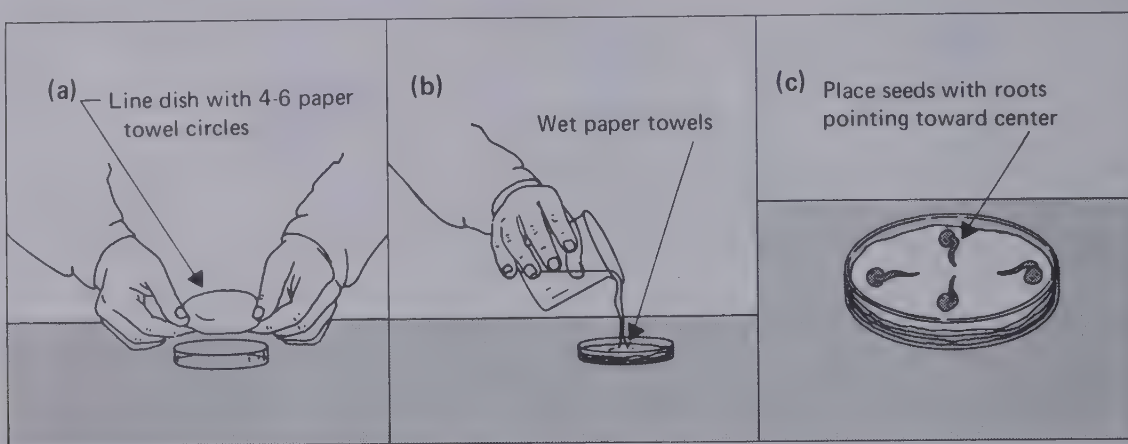
NBC Photo

A. UP, UP, AND AWAY

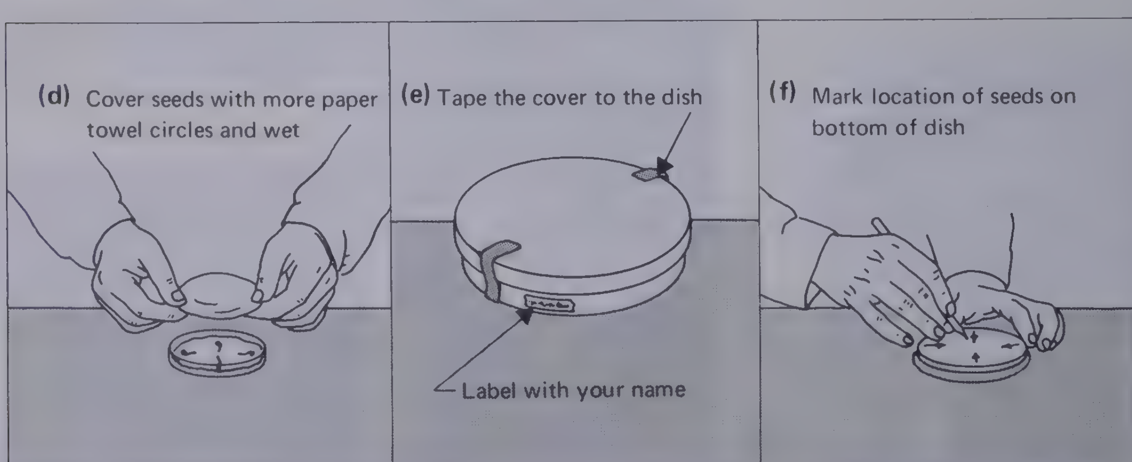
Have you ever seen a plant with its roots up in the air and its leaves under the ground? Have you ever seen an upside-down apple tree? In this Idea, we are going to learn how living things respond as they do.

Obtain four pea or corn seeds with roots that are 1-2 cm long.

Line a Petri dish with 4-6 circles of paper towel. Wet the towels thoroughly. Place the seeds on the wet towels so that the ends of the roots point toward the center. Make a drawing of the arrangement of the roots in space *a* of your data sheet.

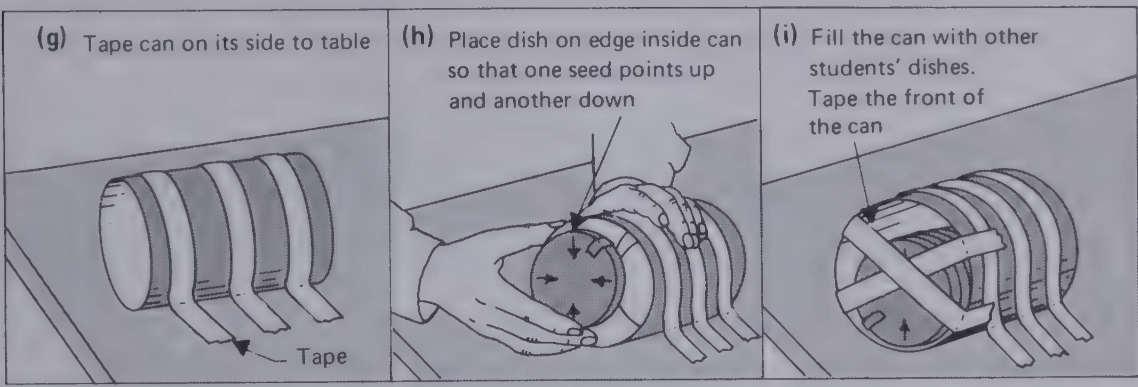


Cut 4-6 more paper towel circles. Gently cover the four seeds with these towels. Wet them thoroughly, too. Place the cover of the dish in position and tape it shut. Mark the direction of the roots on the bottom of the dish. Label the dish with your name.



Place the dish on its edge inside a can. Turn the dish so that one root points up, another down, and the remaining two are pointing in from the sides. The dishes from the other

students should be placed in the cans in the same way. Tape the cans so that the dishes will not fall out. Then tape each can to the table to keep the seeds in their proper positions.



1. What do you predict will happen to the roots?

After 1-2 days, open the dish and observe the direction of the roots. In space *b* on your data sheet make a drawing of what happened.

2. Do your observations support your prediction? How?

The roots of a plant are very important. They help anchor and hold a plant down. Roots also absorb water and minerals.

3. What do you think might happen to a plant if its roots did not respond like those drawn in space *b*?

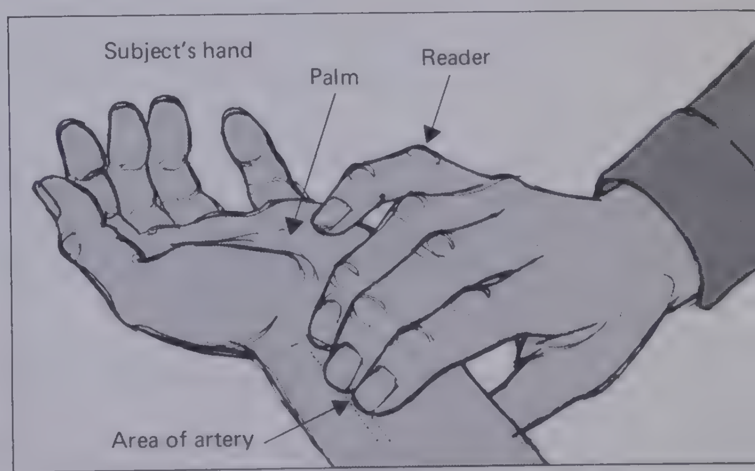
In the experiment you have just finished, the roots responded by growing in the same direction. The cause of this response might have been gravity. The cause of each *response* is called a *stimulus*.

B. A REAL WILD BEAT

You have probably had your pulse rate taken by a doctor or a nurse. Your pulse rate indicates how many times your heart is beating each minute. Every time the heart beats, it pushes blood into tubes called *arteries*. One of these arteries extends into your arm and comes close to the skin near your wrist.

Find the pulse in your wrist. Do not use your thumb. Use the three middle fingers, as shown in the drawing.

Correct Way to Take Pulse



Take three 1-minute counts of your pulse. The average of these three counts will be your pulse rate taken while you are at rest. When taking the pulse, it is just as easy to take a 30-second reading and multiply the count by two. Record your data in Table 1 of your data sheet.

Exercise for 20 seconds in the way suggested by your teacher. Then take three 1-minute counts of your pulse. Record these three counts and the average count in Table 1.

Next sit in a chair and breathe deeply for one minute. Again, take three 1-minute counts of your pulse and determine your average pulse rate. Record these data in Table 1.

4. What did exercise do to the pulse rate?

5. What did the deep breathing do to the pulse rate?

6. What were the stimuli (plural of stimulus) in the experiment?

7. What was the response in this experiment?

When you say that someone is groovy and in gear, you are probably saying that he is alert and can respond well. A person responds to many different stimuli each day.

8. What do you think might happen to a person who could not respond to a stimulus?

C. WANT TO CRAWL?

This investigation opened with a picture of a plant that responded to sunlight by bending toward it. Are all organisms attracted to light?

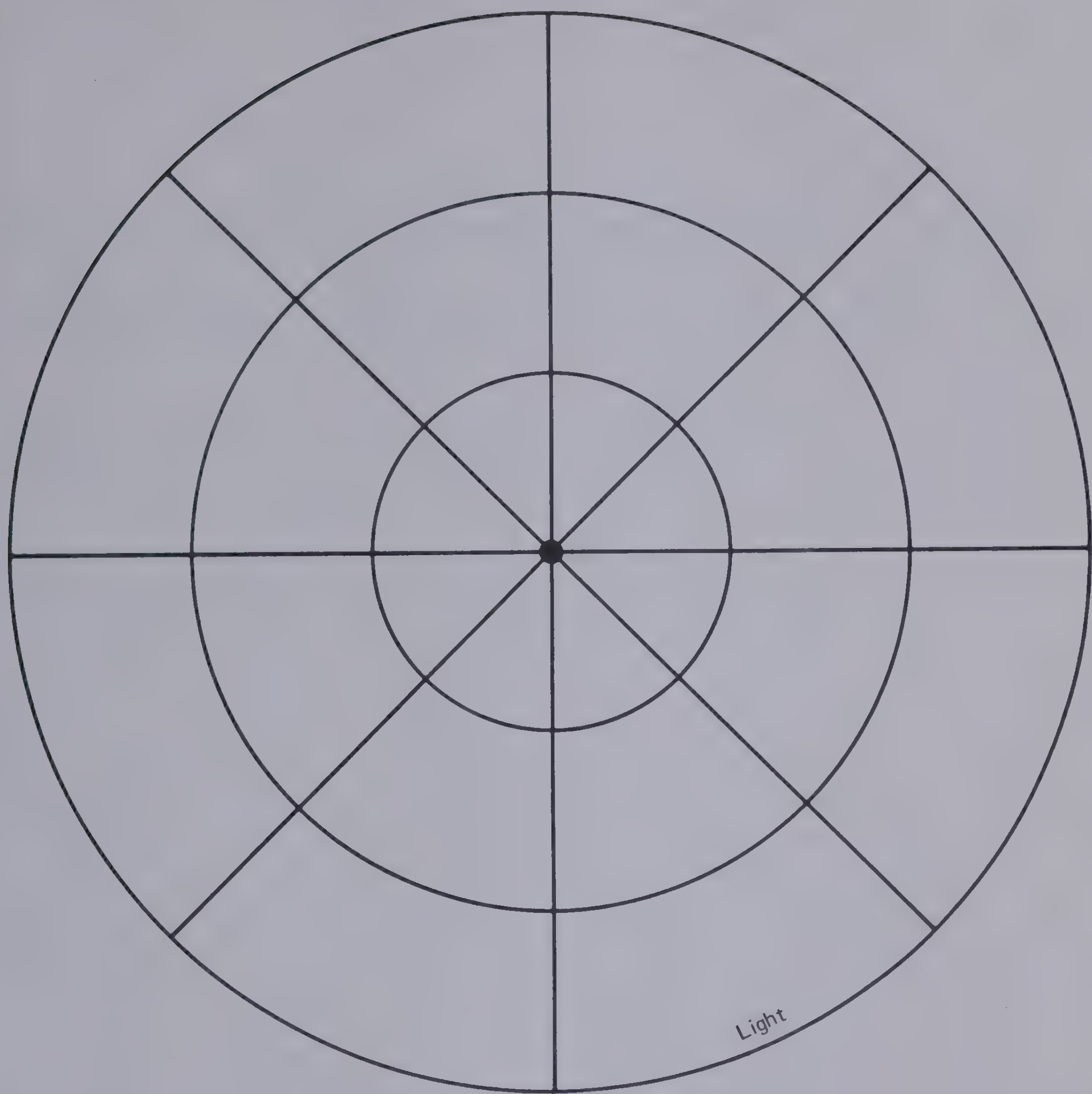
Your teacher will give each group of 2-3 students a piece of plastic. A set of lines and circles are printed on the plastic.

Darken the room. Then put the piece of plastic on a table about 10 cm from a source of light. Be sure the word "light" is pointed at the source of light.

Place a snail in the center of the printed circle. As the snail crawls, record its path on the plastic with a crayon or a felt pen. When the snail reaches the outer circle drawn on the plastic, gently slide the snail off the plastic and return it to the center of the circle. Stop when the snail has reached the outer circle three times or your teacher calls time. Examine the other pieces of plastic used in class.

9. What was the most popular path traveled by the snails in the class?

10. What was the stimulus in this experiment?



11. Were there any other stimuli in this experiment? If so, name them.

12. Was this a properly controlled experiment? Explain.

13. What was the response in this experiment?

14. Why do you think a snail responds in this way?

15. What do you think might happen to a snail that could not respond to a stimulus?

D. YES, I'M WITH IT

If you aren't "with it," you just aren't groovy. Living things have to be "with it" if they are going to respond. Therefore:

16. What is a stimulus?

17. What is a response?

18. From what you have observed in this investigation, what must living things do in order to survive?

CONCEPT SUMMARY. (What general concept have you learned in this investigation?)

Investigation 2

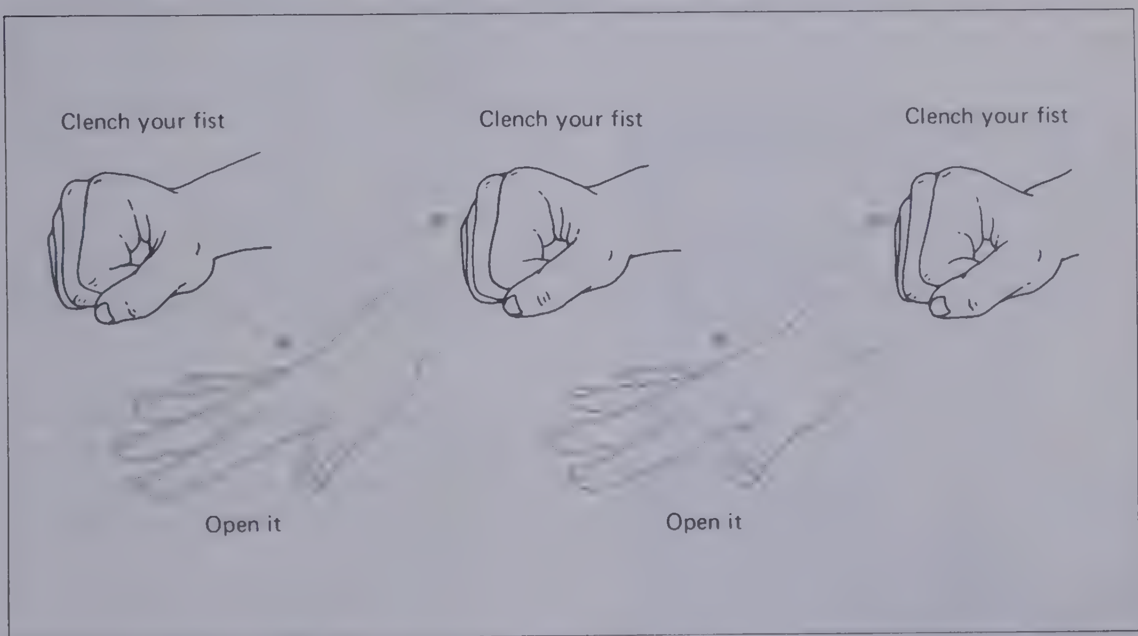
Let's Cool It

In the last investigation, we learned about different stimuli and responses. A stimulus is something that causes an organism to react. An organism's reaction or adjustment is called a response. An organism must react and make an adjustment if it is to survive.

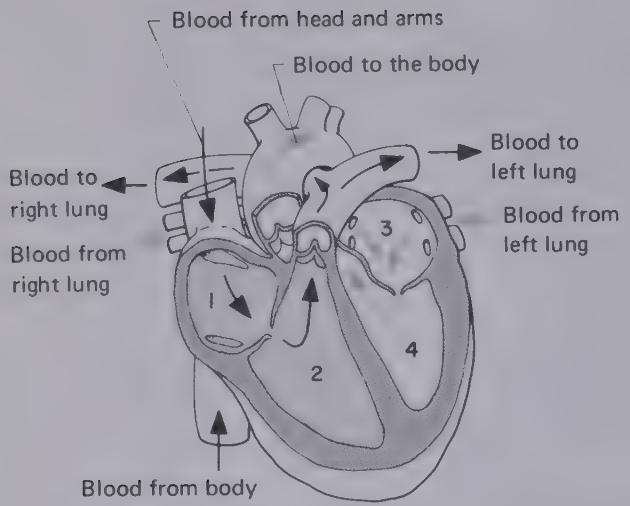
In this investigation we will ask the question, "Are all stimuli and all responses the same?" For instance, will a bright light cause the same response in all animals? Will a moth respond in the same way your snail responded? Will a person's pulse rate and heartbeat rate always increase when stimulated?

A. THE EIGHTY-YEAR-OLD WONDER

Clench your fist. Open it. Clench your fist. Open it. Clench it again.



Look at your fist. Note its size. Your heart is a bundle of muscles about the size of your fist. Now open and clench your fist about 72 times per minute. Imagine doing this all day and all year. That's over 100,000 times a day and nearly 40 million times a year. Imagine opening and clenching your fist continuously for nearly 80 years. This will give you some idea of how much your heart works.



The Human Heart

The heart is divided into four parts called chambers. Blood returns from the body and gathers in the first chamber. The blood then flows through a valve and into a second chamber. Then the heart clenches and the blood is forced out of the heart and into the lungs. The blood that returns from the lungs enters the third chamber of the heart. It is then pumped through another valve and forced into the fourth chamber. It is finally squeezed out into the blood vessels and travels throughout the body.

Note the valve at the exit of each of the four chambers. They are all like one-way doors. The blood can only flow through them in one direction.

We know your heart clenches because a sound can be heard. Each of these sounds is the opening and closing of two of the valves. A doctor can listen to your heartbeat with a stethoscope. He hears a sound like "lub-dub." The type of sound can help tell the doctor the condition of your heart.

You know your heart beats because you felt the movement of blood when you took your pulse in the last investigation.

As you have already learned, your pulse rate can change. Does this mean that your heartbeat can vary, too? What controls the heartbeat rate?

B. A FLEA FOR ME

You will be using a small animal commonly called a "water flea." It is not a flea at all. It is more like a lobster or shrimp and is known as a *Daphnia.* It is very common in some ponds and streams.

Daphnia, 40X

Grant Heilman, Lititz, Pa

As you can see, the *Daphnia* is transparent (you can see through it). You can even see something beating at the top. This is the heart. It beats very rapidly, over 300 times per minute.

With a dropper, place one *Daphnia* on a slide. Place some cotton fibers in the drop, too. They will trap and prevent the *Daphnia* from swimming around.

Find the *Daphnia's* heart under the low power of your microscope. Reduce the light and you will see the transparent heart

better. This will also cut down the heat, which could kill the animal. Do not mistake the beating of the gills for the heart. The heart is very small, clear, and at the top of the animal.

Count the heartbeat rate for three 1-minute periods. Because the heartbeat rate is so fast, it is suggested that you count the beats for 30 seconds and multiply your count by two.

Determine the average of these three numbers and record this number in Table 1 of your data sheet as the control heartbeat rate.

Your teacher will supply you with a chemical substance. Write the name of this substance on the second line in Table 1. Using a dropper, place a drop of this substance at the edge of the cover slip, where it meets the slide. Wait 10-15 seconds for the substance to flow under the cover slip. Count the heartbeat rate as you did before and enter your result in Table 1.

Transfer the *Daphnia* back into another jar. These will be "used" *Daphnia.*

If time permits and there are enough *Daphnia,* you may be asked to test other chemical substances. If you do, be sure to: 1) rinse your dropper thoroughly, and 2) use a new *Daphnia*. Record your data in Table 1.

Record the class data in Table 2.

1. Which chemicals caused the heartbeat rate to increase?

2. Which chemicals caused the heartbeat rate to decrease?

3. What was the stimulus in this experiment?

4. What was the response in this experiment?

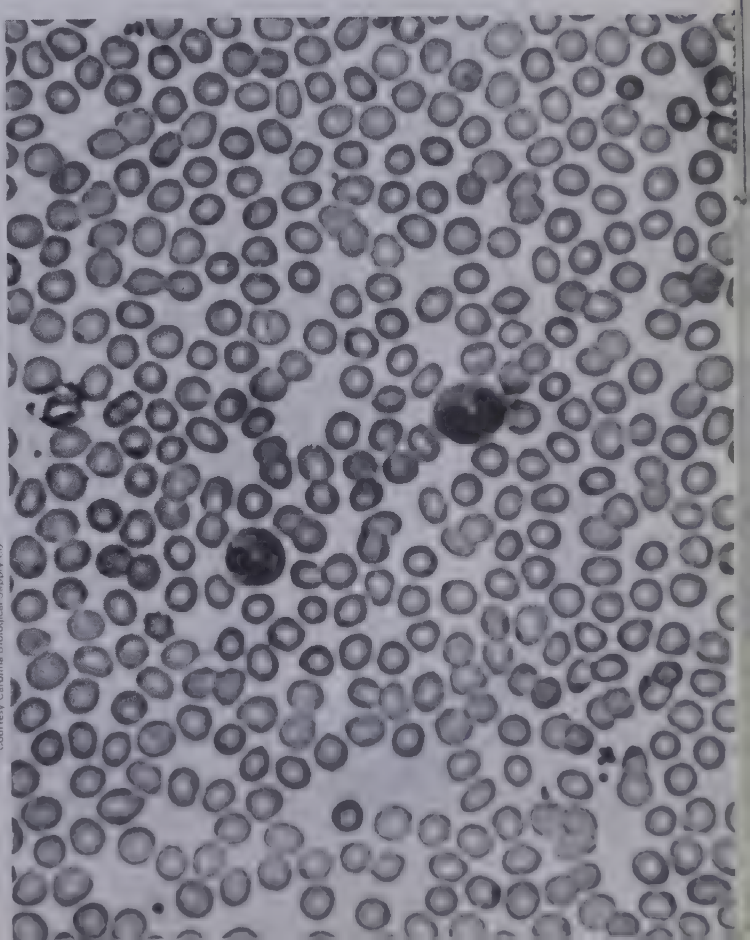
5. What will different kinds of stimuli cause?

C. SEVENTY THOUSAND MILES OF TUBING

The blood in your body can be separated into two main parts. A little more than half of the blood is the liquid called plasma. The remainder of the blood is made of red and white blood cells.

The red cells get their color from a material called *hemoglobin.* The hemoglobin carries oxygen to the cells and picks up carbon dioxide. If a person does not have enough red blood cells or hemoglobin, his cells will not get enough oxygen. This lack of enough red blood cells is called *anemia.*

Human Blood



Courtesy Carolina Biological Supply Co

Dr. Charles R. Drew Helped to Develop the First Blood Plasma Bank in World War II

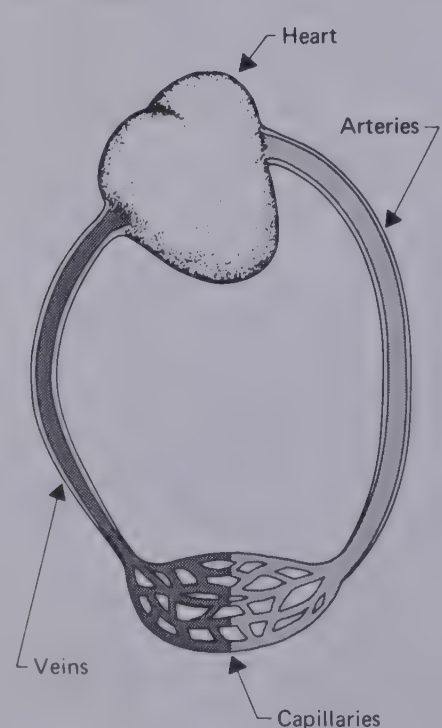
The white cells are important because they defend the body against invasion by bacteria. They are the soldiers of your body.

Finally, plasma, the liquid part of the blood, carries dissolved food materials, waste products, water, and special cells which help blood to clot.

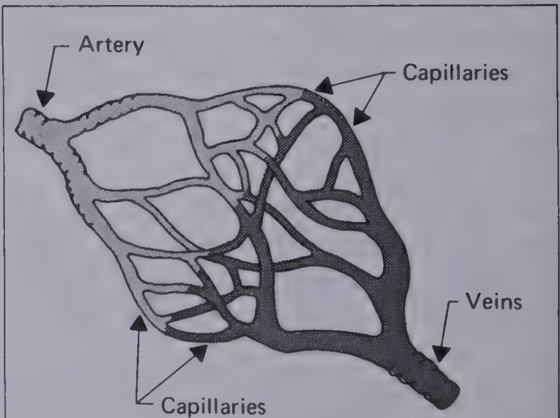
Your blood is contained in a gigantic transportation system. Its function is to carry materials to and from the cells. The blood moves around the body by way of tubes. The "plumbing" or circulatory system has a master pump. This is the heart.

There are three kinds of tubes that transport blood. The tubes that leave the heart are called *arteries.* They branch into smaller arteries as they wind their way throughout the body.

Finally, the arteries become so small that they branch into even smaller tubes called *capillaries.* The transfer of all materials takes place within the capillary networks. The capillaries are so small that the red blood cells have to travel in single file. It would take a good-sized drop of blood nearly an hour to pass through a capillary. The tiny capillaries then join together, like small streams that feed into a river. The tubes that head back toward the heart are called *veins.*

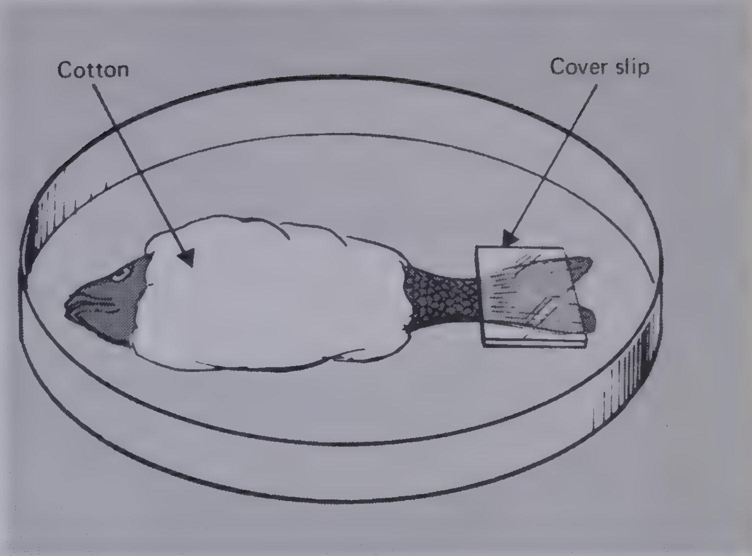


The capillaries bring the blood directly to each cell. The exchange of gases, food, chemicals, and other materials takes place at the capillaries.



D. A FISHY TALE

Wrap a goldfish (except for the mouth and tail) in dripping cotton. Place the fish in the bottom half of a Petri dish and cover a thin region of the tail with either a cover slip or slide. Do not let the cotton dry. Use a dropper to add more water as it is needed.



Place the dish on your microscope stage and focus under low power. Note the movement of blood through the tiny tubes. These are the capillaries.

Try to remember the speed of the blood flow and the size of the capillary.

Your teacher will supply you with a chemical substance. Write the name of this substance on the first line in Table 3. Using a dropper, place a drop of this substance at the edge of the cover slip or slide which is over the tail. Wait 10-15 seconds for the substance to flow under the cover slip.

See if the chemical substance affects the speed of the blood flow and the size of the capillary. Record this observation on the first line in Table 3.

Rinse the tail of the goldfish thoroughly before you place him gently back into the aquarium. Record the class data in Table 4.

6. Which chemicals caused the blood flow to decrease?

7. Which chemicals caused the capillary to become smaller in size?

8. Which chemicals caused the blood flow to increase?

9. Which chemicals caused the capillary to become larger in size?

10. What was the stimulus in this experiment?

11. What was the response in this experiment?

12. What will different kinds of stimuli cause?

E. THEY EACH DO THEIR THING

Early in this investigation the question was posed, are all stimuli and responses the same? You have used a number of different chemical substances in this investigation.

13. What does each chemical substance represent in this investigation?

14. How did the *Daphnia* and the goldfish respond to each stimulus?

15. Therefore, what can you say different kinds of stimuli can cause?

CONCEPT SUMMARY. (What general concept have you learned in this investigation?)

Investigation 3

No Sweat

Dogs have often been called man's best friend. If lost, they may travel for miles and find their way home. Sometimes people get lost, too. When this happens, dogs may be used to help find them. The dog smells something that the lost person has worn. From this scent, the dog may be able to track down the lost person. How is this possible?

A. LET IT ALL "PORE" OUT

Why do you sweat? When do you sweat? How do you sweat?

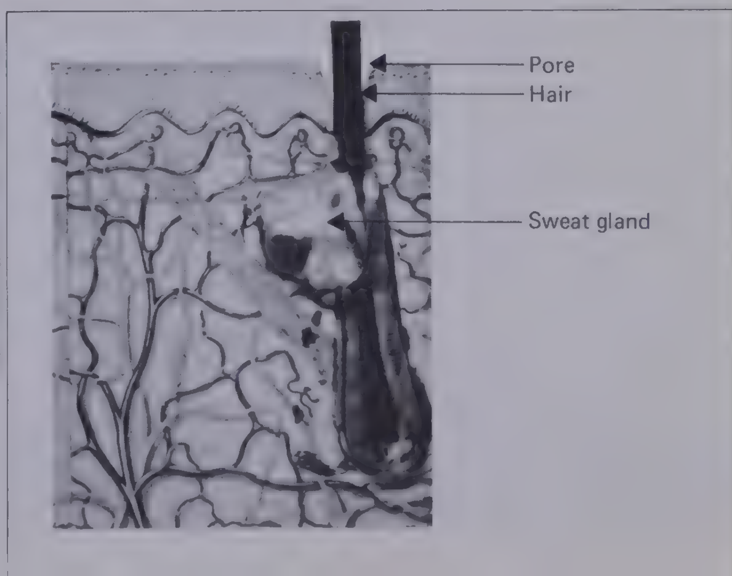
Choose various parts of your skin where you think sweating may occur. Some excellent areas include the palm, upper forehead, underarm, and neck. Using a cotton swab or piece of towel, paint different areas (about 2-3 square cm) with iodine. Allow the iodine to dry.

WARNING: IODINE IS A POISON AND A STAINING AGENT. KEEP IT AWAY FROM YOUR MOUTH AND CLOTHING.

Walter Chandoha

Warm some areas of your skin which have the iodine spot. You might stand next to the heating system or near a light bulb. Keep some other areas painted with iodine cool. For example, if you use the palms of your hands, warm one hand but not the other.

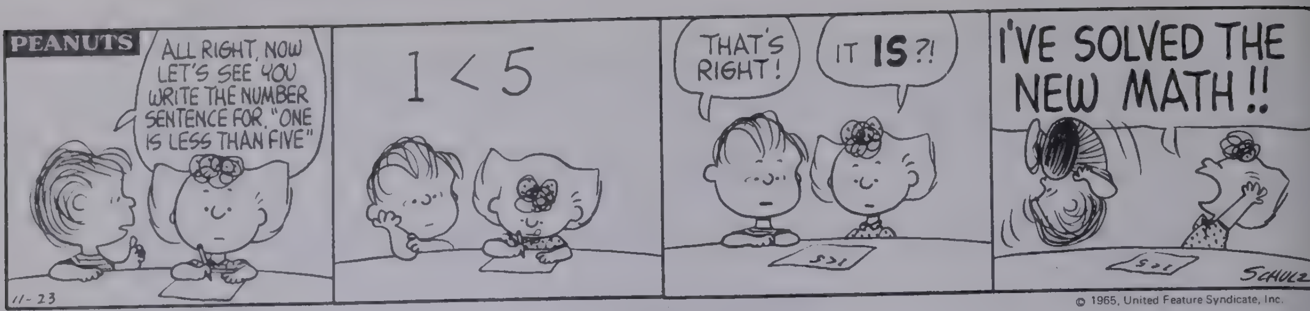
Sweat Gland Pore



Dept. of Dermatology, Medical Center, University of Cincinnati

Five minute's of heat directed toward one area is enough. If sweating has occurred, blot the iodine spot lightly. Then place 5 cm squares of bond paper on the iodine spots and hold them there for 30 seconds.

When you remove the papers, examine them for blue dots. These dots represent active sweat gland pores. Bond paper contains starch and the iodine reacts with it.



Mark off two or three areas of 1 cm square on the bond paper. Count how many dots are in each square. Calculate the average and record the data in Table 1 of your data sheet.

If you or your partner wish to repeat the experiment, there is room in the table for another set of data.

1. Where were the sweat glands most active?

2. Where were the sweat glands least active?

3. What was the stimulus in this experiment?

4. What was the response in this experiment?

In the last investigation you learned that the blood serves as a transportation system. It carries such things as oxygen, carbon dioxide, dissolved food, and waste products. In addition, the blood carries heat to keep the body at a fairly steady 98.6°F. What does your body do if your temperature rises a few degrees above 98.6°F?

5. Why do you think you sweat?

B. WELL, BEND MY KNEE

Repeat the sweat gland experiment in part A by exercising for 30 seconds to one minute instead of using a heat source.

Here is a reminder. Lightly blot the area where the iodine spot was placed before applying the bond paper square. This will prevent smudging. Record your data in Table 2.

6. Did the sweat glands in the different locations differ in activity? Explain.

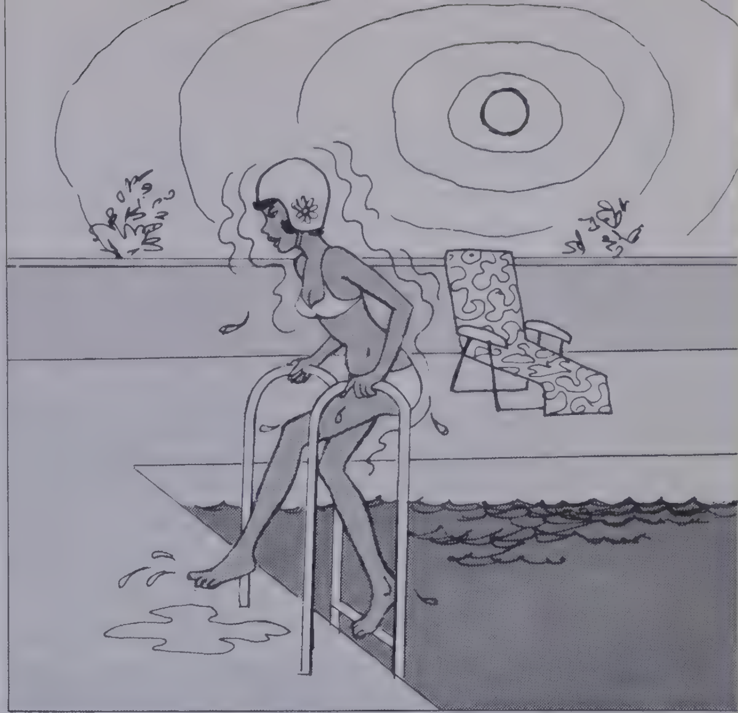
7. What was the stimulus in this experiment?

8. What was the response in this experiment?

9. Why do you think you sweat?

10. Do the data in Table 1 differ from the data in Table 2? Explain.

C. NOW TAKE A SHOWER



You have probably stepped out of a shower or a swimming pool and shivered as if you were freezing. This can happen in a heated house or on a sunny day by a pool.

You may have discovered also that if you wiped yourself off very fast, the coldness disappeared. No, you didn't warm yourself that much by moving your arms and the towel rapidly. You removed the water which was causing the loss of heat. Since the water was cooler than your body, it removed heat from your skin. The skin, of course, got its heat from the blood. As the water evaporated, it took body heat with it. As a result, you felt cold.

You can experience this very easily. Apply a small spot of water to your forearm. Blow on the wet spot, then blow on a dry area. Which area feels cooler? The wet spot is similar to your sweat. It is nature's normal way of cooling you off.

11. How does sweating cool you?

12. How long will a person continue to sweat?

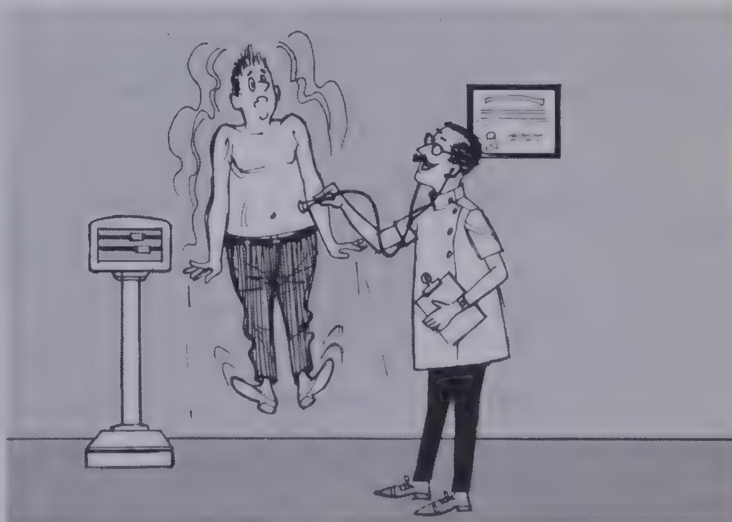
13. What does sweating help keep constant or steady?

There are other reasons for sweating. Sweat helps to remove unwanted chemicals, water and bacteria from the body. This is why sweating is important. What would be the danger of over-using substances that prevent your body from sweating?

(Complete part E and the concept summary now, if part D is not to be done.)

D. IF HE TURNS BLUE, STOP (optional)

"Cold, Eh?"



Let's see if a person's internal temperature changes when his external temperature changes.

Work in groups of four for this experiment. One student will be the subject. One student will take the subject's oral body temperature. The third student will take the subject's skin temperature. And the last student will regulate the water temperature.

Fill a container with cold water. Add ice cubes to the water until the temperature is 10-15° below room temperature. Keep a record of the temperature in Table 3. The student who is assigned this task must keep the water at this temperature. Add ice cubes as the temperature rises.

NOTE: NEVER STIR THE WATER WITH THE THERMOMETER.
USE A STIRRING ROD.

Take the subject's oral body temperature. Keep the thermometer in the subject's mouth for at least three minutes. Record this temperature in Table 3.

Take the subject's skin temperature with the thermistor-thermometer. Your teacher will explain how to use it. Record this temperature in Table 3, also.

Have the subject put as much of one hand and arm into the cold water as possible. Keep his hand and arm in the water for three to five minutes. Do not disturb the subject. Any activity may warm him. Keep the oral thermometer in his mouth at all times.

After three to five minutes, have the subject remove his hand and arm from the water. Quickly damp dry an area on the arm and take the subject's skin temperature. Record the data in Table 3.

Read and record the oral body temperature. The final water temperature should be the same as at the beginning of the experiment. Put these data in Table 3.

14. Did the skin temperature change? If so, how much?

15. Did the body temperature change? If so, how much?

16. Will a change in skin temperature cause a change in body temperature?

17. Despite the cold temperature affecting the skin, what is the body attempting to do?

E. YOU'RE ALWAYS WARM-BLOODED

Despite all the hard work, exercising, and studying you do at school and at home:

18. Your blood and sweat glands help keep what body feature constant or steady?

19. Although body temperature is but one example, what is each response to a stimulus designed to do for a living thing?

CONCEPT SUMMARY. (What general concept have you learned in this investigation?)

Investigation 4

We Must Work Together

Have you ever wondered how a man could function in the heat of Africa and then adjust to the cold of the Arctic?

Did you ever stop to think that if your temperature reads more than 2-3 degrees above or below 98.6°F, you would probably get into bed and might even call the doctor? How does the body maintain its fairly constant condition?

You have seen a number of examples of different responses to stimuli. The changes in pulse rate, heartbeat rate, blood flow rate, and sweat gland activity are a few of the thousands of changes made every second to keep things constant in your body. As long as a constant state is maintained, you remain healthy. Sickness is a sign that some constant state has been upset in your body.

Let's think about the following questions:

a. How does the body know when and how much to respond?

b. What happens if the body cannot respond?

c. If everything is kept constant, how does the body make needed changes, like growing or having a baby?

A. A REAL GASSY AFFAIR

Your blood is part of a big transportation system. In the last investigation, you learned that the blood helps carry heat to keep your body at a fairly constant 98.6°F.

You also studied that the blood carries the gases oxygen and carbon dioxide. Oxygen is carried by the hemoglobin in the blood, the coloring matter of red blood cells.

Carbon dioxide is carried by the plasma, the liquid part of the blood. When carbon dioxide combines with the water in plasma, it becomes carbonic acid. This is the same weak acid found in soda. For this reason, sodas are sometimes called *carbon*ated beverages. You can prove this for yourself.

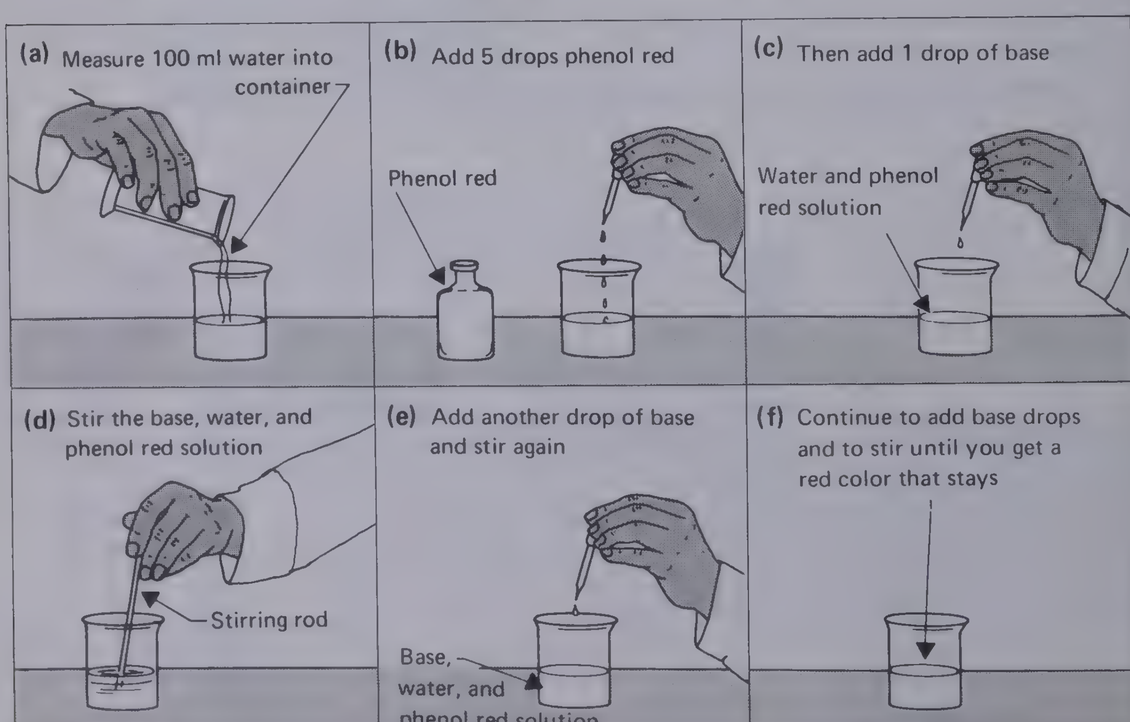
You will be given a dropper bottle of phenol red. Phenol red is used to tell if something is *acid* or the chemical opposite of acid. The opposite of acid is alkaline or *base*.

Measure 100 ml of tap water into a container. Add 5 drops of phenol red.

You will be given such materials as:

Acids	*Bases*
Vinegar	Bleach
Lemon Juice	Lime
Soda	Ammonia

Slowly add a base to the phenol red solution. Stir or swirl the solution after each drop. Continue to add the base until you get a red color that stays.



Now, slowly and carefully, add one of the liquids from the acid group. Stir after each drop.

1. What happens to the color of the water?

Repeat this activity by using a different liquid from the base group.

2. What happens to the color of the water?

Continue to alternate a liquid from each group.

3. What happens each time?

Phenol red is an *indicator.* It is a chemical that can indicate or tell you something.

4. What does the phenol red indicate?

5. What are the two colors of phenol red, and what does each indicate?

Adjust the color of the water until it is slightly red.

6. What did you add to do this?

Now gently blow through a straw into the water.

7. What change occurs after a few minutes?

8. What do you think you are exhaling into the water?

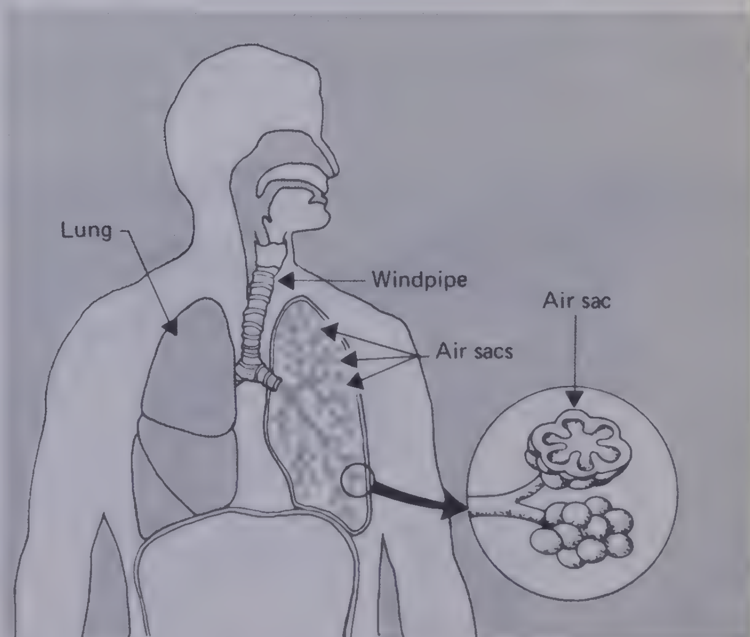
9. What chemical is being formed as you exhale into the water?

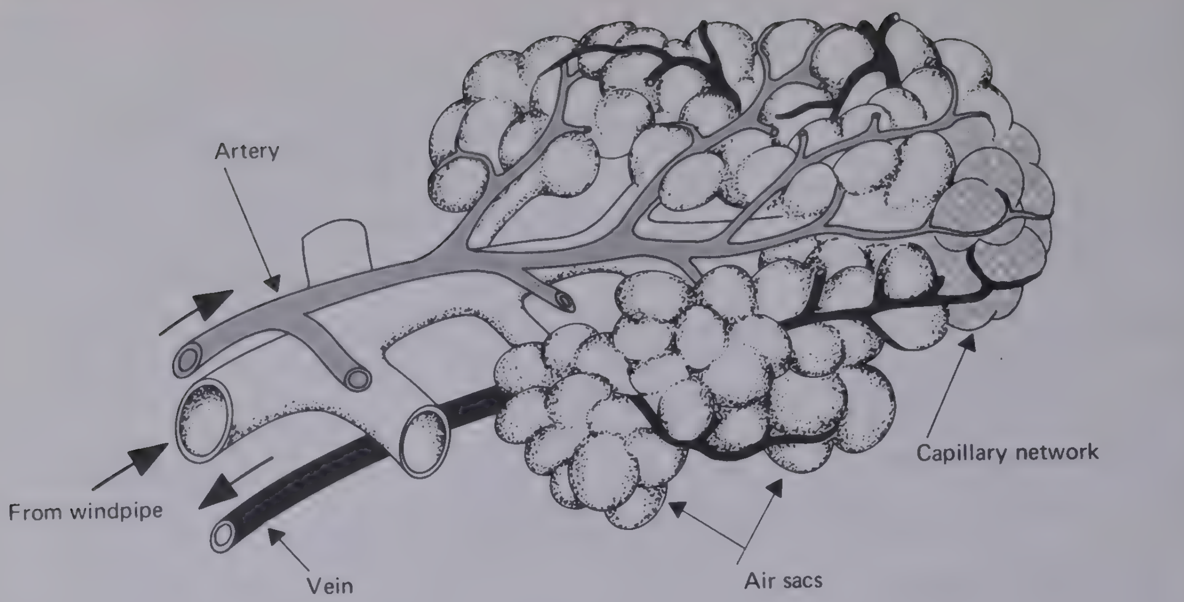
B. MAN CANNOT LIVE ON BREAD ALONE

Man can live for weeks without food. He can live for days without water. But he can exist without oxygen for only a few minutes. (Why you need oxygen will be the subject of Investigation 5.)

How does your body obtain the oxygen that it needs? Air enters your nose or mouth and travels down the windpipe. The windpipe branches and enters both lungs. The tubes continue to branch into smaller tubes. Finally, the tubes become microscopic in size. At the end of each of the microscopic tubes is a tiny sac. There are millions of these tiny sacs in each lung.

Respiratory System





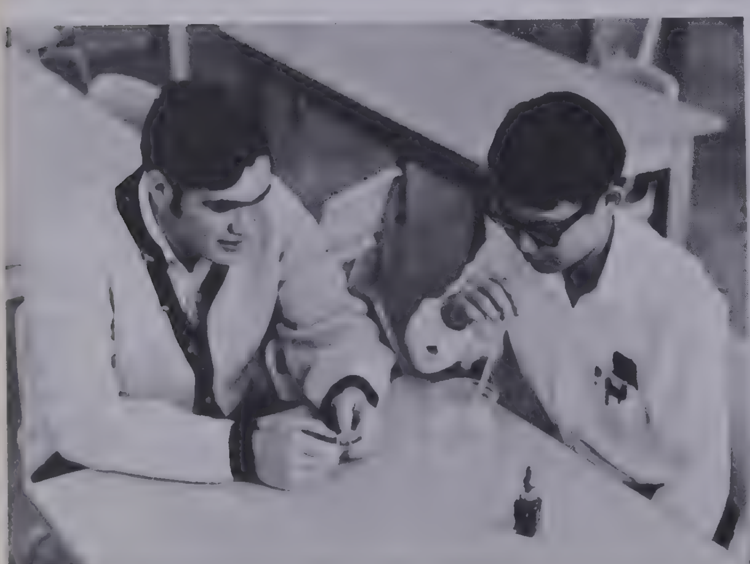
Surrounding each tiny air sac is a network of capillaries. When air is breathed into the lungs, the oxygen passes from the air sacs to the capillaries. When you exhale, the carbon dioxide passes from the blood in the capillaries to the air sacs and then out of the body.

You will need to work in pairs for this experiment. One person will be the subject and the other will be the reader and recorder.

Take the subject's pulse rate and record this in Table 1 of your data sheet.

Also record the normal breathing rate. Consider that one breath = 1 inhale and 1 exhale. Determine the breathing rate for three 1-minute periods and calculate the average. Both the pulse rate and the breathing rate should be taken while the subject is sitting down and at rest.

Fill a container with 100 ml of water. Add five drops of phenol red. Add enough base to turn it red. (Put only enough base in the water to make it stay red.)



Have the subject exhale normally through the straw into the red colored water. In Table 1, record the exact time it takes for the water to become yellow.

Add enough base to turn the water back to red again. Have the subject exhale normally again through the straw into the red colored water. Record the exact time it takes to turn the water yellow. Record this time in Table 1. Calculate the average for these two readings.

The subject is now to exercise for 20-30 seconds. While the subject is doing this, add base to turn the liquid back to red.

Now take the subject's pulse rate and breathing rate. Record these data in Table 1. Then have the subject exhale normally through the straw. Record the exact time it takes to get rid of the red color.

Quickly change the liquid back to red, exhale again and determine the exact time it takes to turn the water yellow. Record this time. Calculate the average for these two readings. (If the recorder wishes to be the subject of these experiments his data can be placed in Table 1, too.)

10. What happened to the breathing rate after exercising?

11. Can you explain why the breathing rate changed? Hint: What gas was the body trying to get rid of?

12. What happened to the pulse rate after exercising?

13. Can you explain why the pulse rate changed? Hint: How are gases carried throughout the body?

14. Did the red liquid turn yellow faster or slower after exercising?

15. Can you explain why the red liquid turned yellow faster or slower? Hint: What is soda?

16. What do you think will happen to the pulse rate, breathing rate, and amount of gas in the blood after a length of time?

C. NO MAN IS AN ISLAND

We live in a society where we are encouraged to work together. It is difficult to live alone without depending on others. The same is true of the different functions that take place in the body.

In previous investigations, you observed separate functions of your body. You saw the pulse rate in one experiment, the heartbeat rate in another, and the blood flow rate in still another.

In this investigation you saw a number of functions operating together. Three things were observed—the pulse rate, the breathing rate, and the changing amount of carbon dioxide in your body. Are these three things related to each other?

17. When you work or exercise, what waste gas is produced in excess by the cells of your body?

18. What takes the waste gas away from your cells?

19. In order to get rid of excess waste gas, what should happen to the pulse rate?

20. What does this indicate is happening to the heart?

21. What should happen to the blood flow rate? Why?

22. What should happen to the breathing rate? Why?

23. Name the activities that function together to get rid of waste gases.

The different body functions cannot operate by themselves. They must work together.

24. What are the different body functions working together to do?

CONCEPT SUMMARY.

Investigation 5

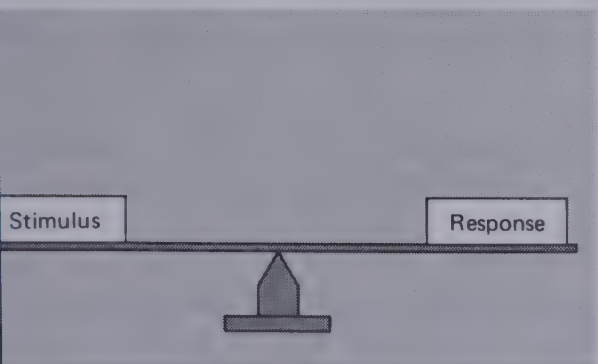
The Biggest Put-On In Life

Have you ever watched a circus performer walk a tightrope above a crowd of tense onlookers?

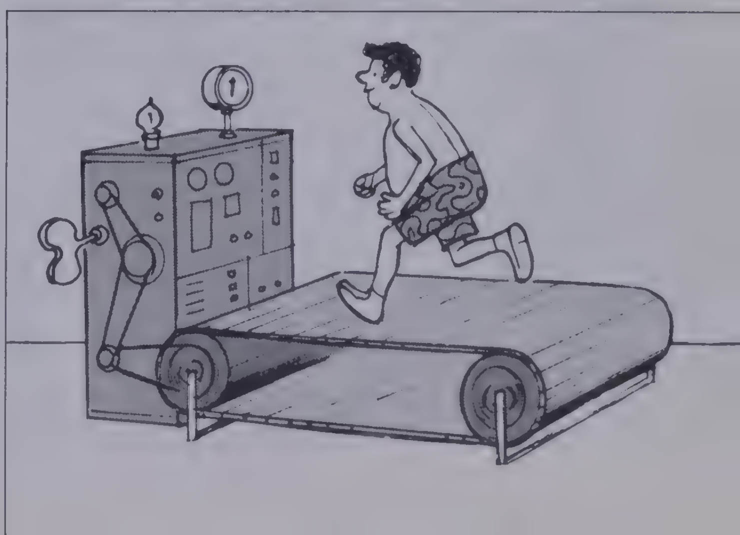
Every step requires perfect balance. If you watch the performer closely, you may notice that he sometimes leans slightly to the left or to the right. He adjusts his balance as he takes each careful step. Balance and adjustment to maintain balance—these are the basic skills in tightrope walking.

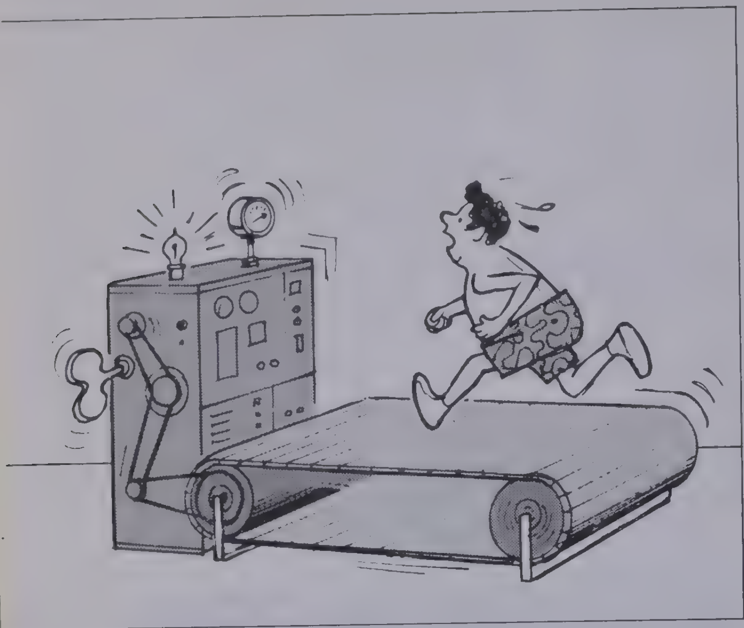
In a sense, every living thing walks a biological tightrope. Living things must maintain a delicate balance in the face of constantly changing conditions.

The ability of an organism to adjust and maintain a balanced condition inside the body is called *homeostasis.* Survival depends on the body's ability to maintain homeostasis.



The most important thing to understand about homeostasis is that there is constant activity inside the body. The purpose of the activity is to keep the body's condition balanced or steady. It takes work just to stay in balance. In fact, it sometimes takes work just to stay in one place.





If the treadmill goes faster, what must the runner do to stay in the same place? What if the treadmill goes slower? How must the runner respond? What if the runner gets tired or the treadmill turns faster? Suddenly, a condition exists which threatens to upset the balance. What happens if the runner cannot respond?

You may be faced with threatening conditions every day. Some examples are temperature changes, presence of harmful germs, an organ wearing out, polluted air, and overwork. If the threatening condition is greater than your body's ability to adjust, what may happen?

A. THE BREATH OF LIFE

Do the following experiments in groups of 2-4 persons. There should be a smoker and a nonsmoker in each group. Begin with the nonsmoker first.

CAUTION: STUDENTS WITH BREATHING DIFFICULTIES SHOULD ACT AS RECORDERS DURING THE FOLLOWING ACTIVITIES.

Normal Condition: Have the subject sit quietly in a chair. Take his pulse while he counts his own breathing rate per minute. Repeat your count 2-3 times and take the average. Record the average pulse and breathing rates in Table 1 of your data sheet.

Exercising: Have the subject exercise for 1 minute, in the way suggested by your teacher. Immediately afterwards, take the subject's pulse while he counts his own breathing rate. Record the data in Table 2.

After two minutes, take the pulse and breathing rates again. Continue taking counts every two minutes until the subject's rate is back to his normal rate shown in Table 1. Record each count in Table 2.

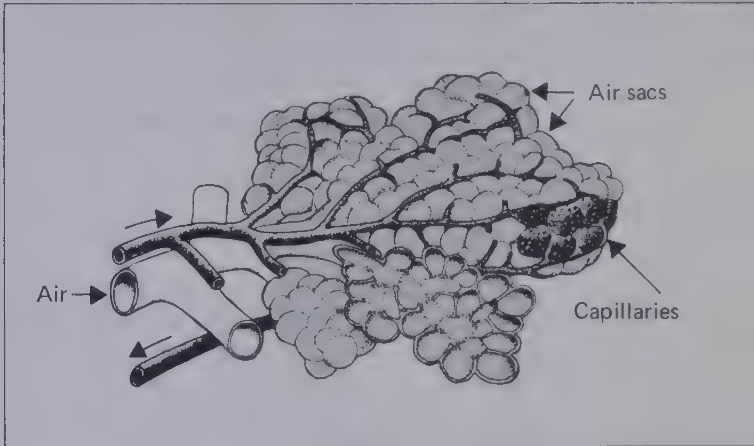
Repeat the entire experiment with the smoker as the subject. Work carefully since the results for both subjects will be compared.

Record the class data in Table 3.

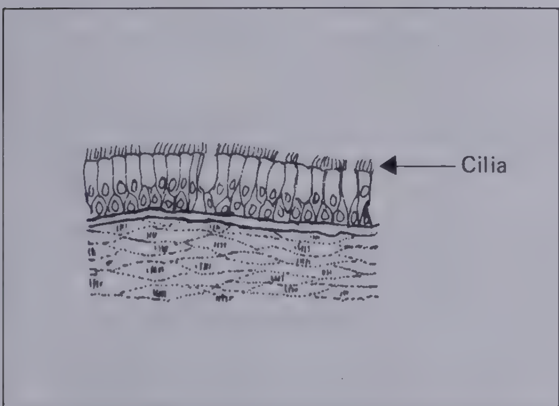
Before questions are asked about the class data, you should know about some research that has been done on the lungs.

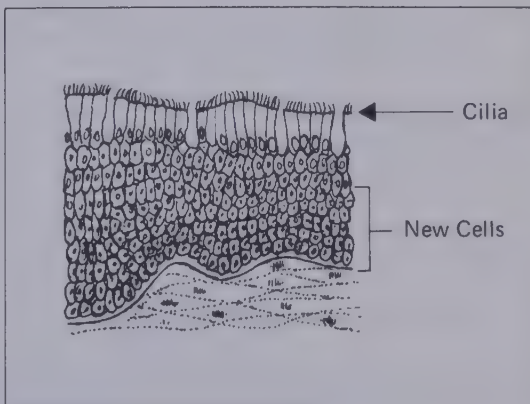
Air from outside the body travels through a windpipe which branches into both lungs. The branching continues until the tubes become microscopic and finally end as a cluster of air sacs. Blood capillaries are attached to the surface of these air sacs. It is here that oxygen and carbon dioxide are exchanged with the bloodstream.

Air Sacs Within the Lungs



Look at the microscopic view of the tiny tubes in the lungs. These tubes are two cells thick and are lined with tiny hairs called cilia.





Early in the 1960's, a number of scientists in New York and New Jersey made microscopic studies of the tiny tubes in the lungs of people who had died. What they found in some of the lungs is shown to the right above. Note that layers of new cells have appeared and the lining is very thick. In addition, these cells are hardened, like calluses on the hand. Their findings are summarized in the table.

Degree of Smoking	Rate of Hyperplasia*, %
None	10-18
Light Smokers	80
Heavy Smokers	95

*An increase in the number of cell layers lining the air passages in the lung.

1. Summarize their data in one sentence.

As the data show, almost all smokers have a thickening and hardening of the cells lining the air tubes in the lungs. Thicker linings result in tubes with smaller openings. Smoke also irritates tube linings causing them to give off a fluid called *mucus.* The smaller tubes can become plugged with the excess mucus.

2. What happens to the movement of air in the lungs when the air tubes are plugged or reduced in size?

The scientists also found that smokers coughed a lot to get rid of excess mucus. Their coughing caused air to become trapped in the air sacs. As a result, the air pressure inside the air sacs increased and the sacs broke. Broken air sacs are as useless as broken balloons. Microscopic studies showed that smokers had a larger number of broken air sacs than non-smokers.

3. What happens to the air capacity of the lungs when many of the air sacs are broken?

4. What do you predict the heart will have to do to make up for this?

With this background, look at your own data and the class data in Tables 2 and 3. Answer the following questions.

5. What happened to the pulse and breathing rates after exercising?

6. You learned in a previous investigation that a waste gas is produced during exercise. What is the gas?

7. How would you explain the change in the breathing rate after exercising?

8. How would you explain the change in the pulse rate after exercising?

9. Did it take the smokers or the nonsmokers longer to return to their normal pulse and breathing rates after exercising? Explain why.

Athletes train to build up their wind. What does this mean? Although jogging is good for the leg muscles, chinning is better for the lungs. Why?

10. When you inhale and exhale very deeply, what do you do to the air capacity of your lungs?

11. What do you do to the amount of stale air that normally is in the lungs?

12. How does deep breathing help an athlete increase his stamina or keep him from getting tired fast?


Wide World Photos

The 1968 Olympics were held in Mexico City, which is more than a mile above sea level. (At this height, there is less air and less oxygen.) During the events, there were frequent cases of athletes dropping out from exhaustion. They were just too tired to continue.

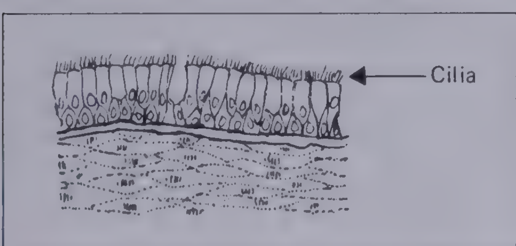
To prepare for the Olympics, the United States' team spent weeks training at Lake Tahoe in California. The altitude at that location is also more than a mile above sea level. An excellent example of homeostasis could be seen at this altitude. First, a threatening condition existed. There was not enough oxygen being supplied to the cells. The red blood cells were not carrying their full supply of oxygen.

As each athlete practiced at this altitude, his body began to make an adjustment. The body could have adjusted by having the heart beat faster. This would have circulated the blood faster, carrying more oxygen to the cells. But this would have overworked the heart. Instead, the body produced extra red blood cells. These cells were able to carry more oxygen. Thus, the athletes were able to go to Mexico City with more red blood cells and in better physical condition.

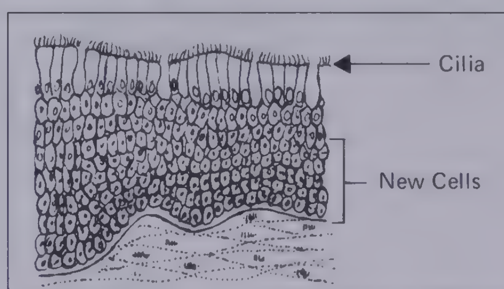
B. JUST TOO MUCH TO ADJUST

There is now much evidence to show that smoking might cause the following things to happen. The stages illustrated usually take many years to develop. This is how lung cancer develops.

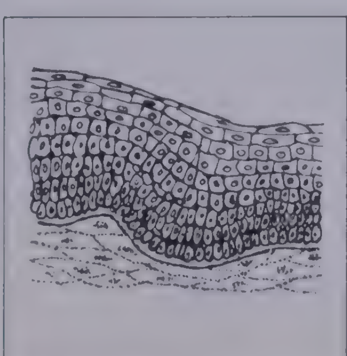
Walls of the Air Tubes Are Only Two Cells Thick



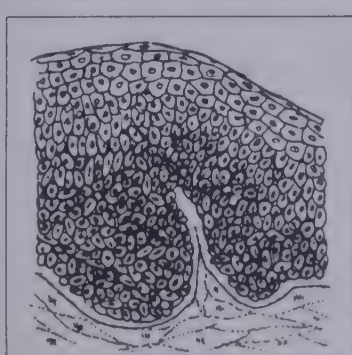
Hardened Cells Form



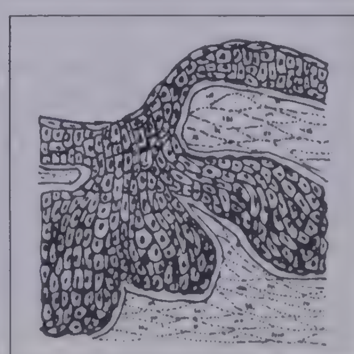
Cilia Disappear and Cells Become Flat in Shape



Cells Become Disorganized and Nuclei Do Not Look Normal. The Cells are Now Cancerous



When the Cells Break Loose, They Can Spread Throughout the Body and Start Cancerous Growths Elsewhere



"Should a Gentleman Give a Lady Lung Cancer?"

"I'd Walk a Mile—If I Had the Energy."

C. DON'T RIDE THE BRAKES

Every driver is taught not to ride his brakes. If he does, the extra strain will wear out the brakes or engine. Your body is no different. Look at your data comparing the smokers with the nonsmokers.

John Gallagher

"I Think He's Out of Cigarettes."

13. Which group, the smokers or the nonsmokers, has a faster breathing and pulse rate? Explain why.

14. Which group is probably putting a greater strain on the heart? How?

15. Which group takes longer to return to normal? Explain why.

Every time a person smokes he introduces a stimulus. The body responds by trying to return to its normal state. Each response requires some work.

You have seen the relationship of smoking to the breathing system. However, the purpose of this investigation has been to show you what extra strain can do to the body's constant state.

16. What will happen to the body's constant state if it has extra strain?

CONCEPT SUMMARY.

Investigation 6

Keep Your Cool and Keep It Steady

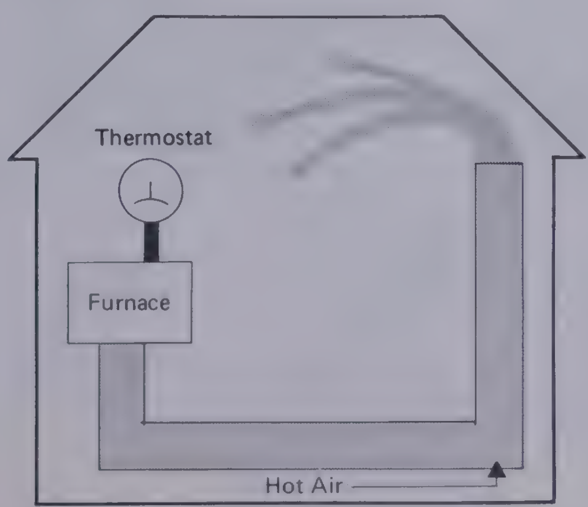
The sign says, "Signals set for 30 mph." If you drive any faster or slower than a steady 30 mph, you'll find yourself stopping at red lights. So you give your speedometer frequent glances, while adjusting your foot on the gas pedal to keep the car at 30 mph.

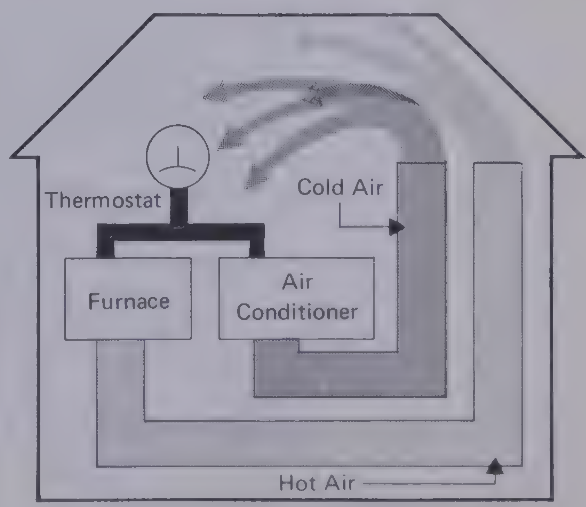
Your foot on the accelerator, controlling the speed of the car, is similar to a *thermostat* controlling temperature. Thermostats are found in toasters, coffee makers, ovens, and refrigerators. But you are probably most familiar with thermostats that are mounted on walls in homes, offices, and classrooms. These thermostats are connected to furnaces. When the temperature drops below the temperature set on the thermostat, the furnace is automatically turned on.

An air-conditioner can be added to the system to improve the usefulness of the thermostat. When the temperature goes below or above the temperature set, either the furnace or air-conditioner will go on. This will either heat or cool the room. With this setup, you have something that resembles homeostasis.

Sybil Shackman from Monkmeyer Press Photo Service

Adjusting a Thermostat





Nearly all the processes in your body function in the same way. There is a *balance point.* For example, body temperature is approximately 98.6°F. The heart rate is about 72 beats per minute, and 10-12 breaths per minute is the average breathing rate. The body makes adjustments to keep all the processes at their balance points. (Everyone does not have the same balance points.)

Let's look at the balance points in the digestive system.

A. ARE CRACKERS SWEET?

Imagine a tube that is about 30 feet long. That's about the width of a street or about three stories high in an apartment house. About 20 feet of the tube is as round as your thumb and the largest section is as round as your fist.

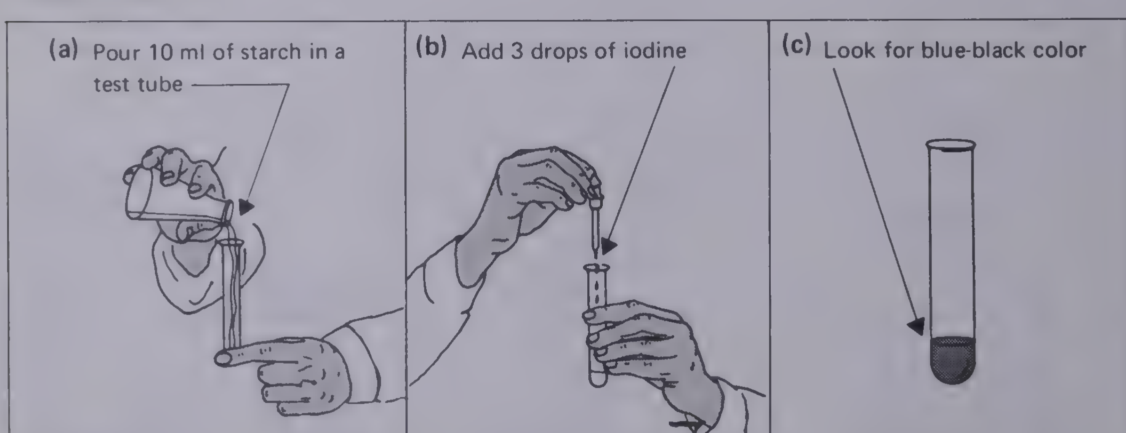
The 30-foot-long tube begins at the mouth and ends at the anus. Between these two points, most of the food that a person eats is changed for use by the body.

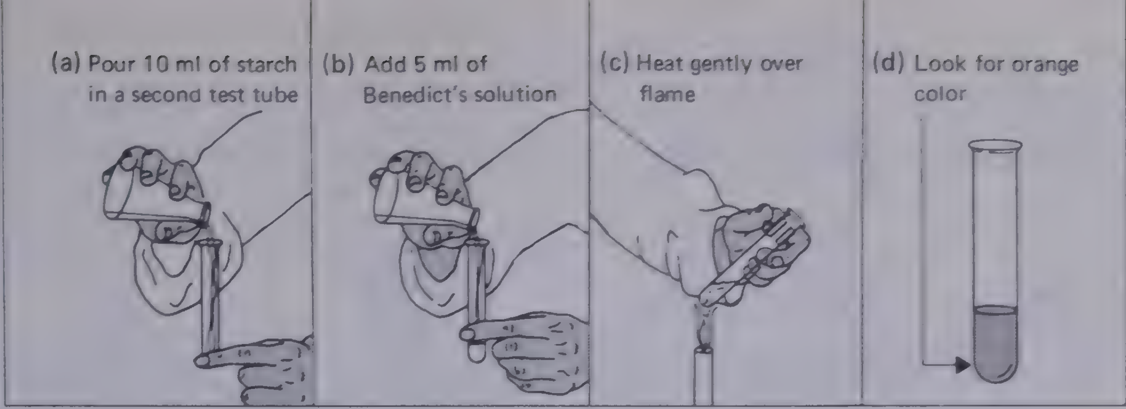
Most foods are proteins, carbohydrates (sugars and starches), or fats. The purpose of digestion is to break down these foods into small particles which can be used by the cells. But how is food broken down by the digestive system?

Let's see how starch is digested.

First, you will have to do the standard starch and sugar tests. Place 10 ml of a prepared starch solution into each of two tubes. Add 3 drops of iodine to one tube. If a blue-black color appears, starch is present. Record your results in Table 1 of your data sheet. Add 5 ml of

Standard Starch Test





Standard Sugar Test

Benedict's solution to the other tube. Using your test tube holder, heat the tube gently over a flame. CAUTION: POINT THE MOUTH OF YOUR TEST TUBE AWAY FROM YOURSELF AND YOUR NEIGHBORS. If an orange color appears, sugar is present. Record your data in Table 1.

Now collect about 5 ml of saliva. Test this saliva for sugar and record your results in Table 1.

1. What do your tests show about the presence of sugar in starch and in saliva?

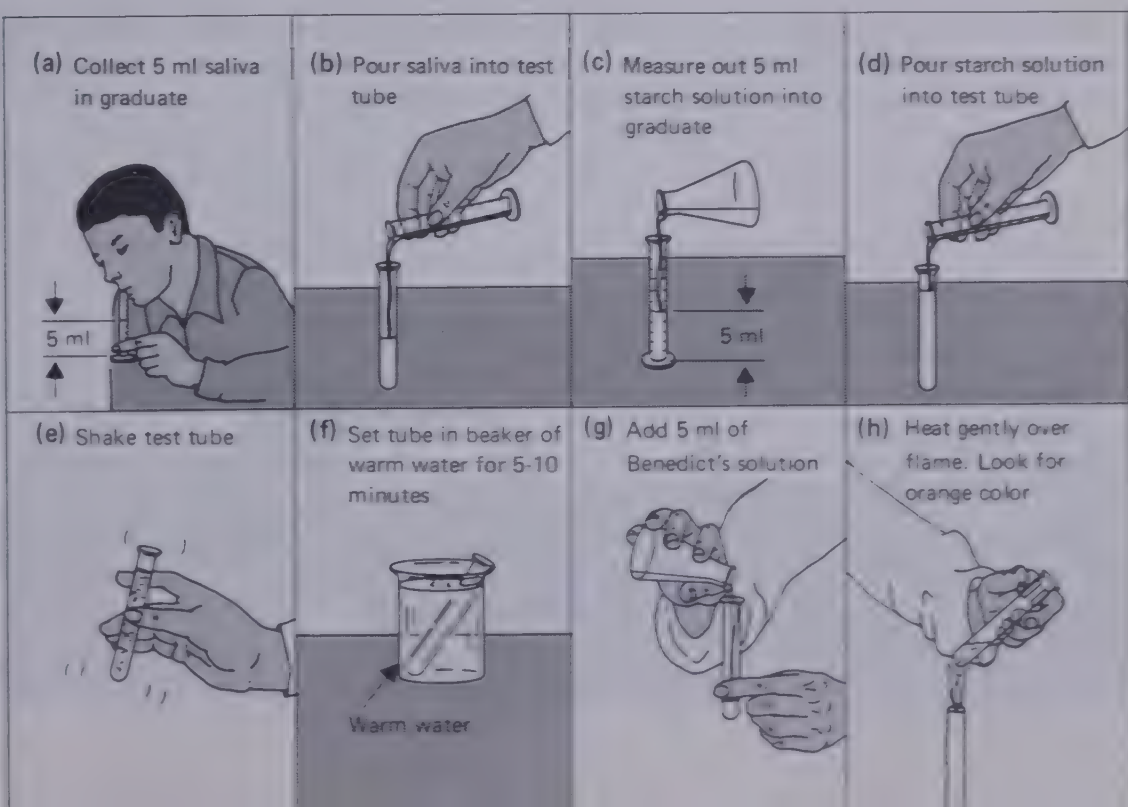
In a clean tube, collect another 5 ml of saliva. Add an equal amount of starch and shake. Set the tube in a beaker of warm water for 5-10 minutes.

2. What change do you notice in the liquid?

Test the contents for the presence of sugar.

3. Is there any sugar in the starch-saliva solution?

4. What might have happened to cause the result noted in "3"?



Take a dry cracker or a piece of bread and chew it. Note the flavor when you start to chew. Do not swallow the cracker or bread. Instead, chew it for at least 3-5 minutes.

5. What change in taste do you notice?

6. How would you test your observation to be sure? Go ahead and try if you wish.

7. How would you explain the change?

There are two major groups of carbohydrates—starches and sugars. Crackers, bread, and potatoes are carbohydrates. More specifically, they are starches. Starch is a very large chemical molecule. It can be broken into smaller molecules by chemicals that are released into your digestive tube. These chemicals are called *enzymes.* You have just seen an enzyme in your saliva at work.

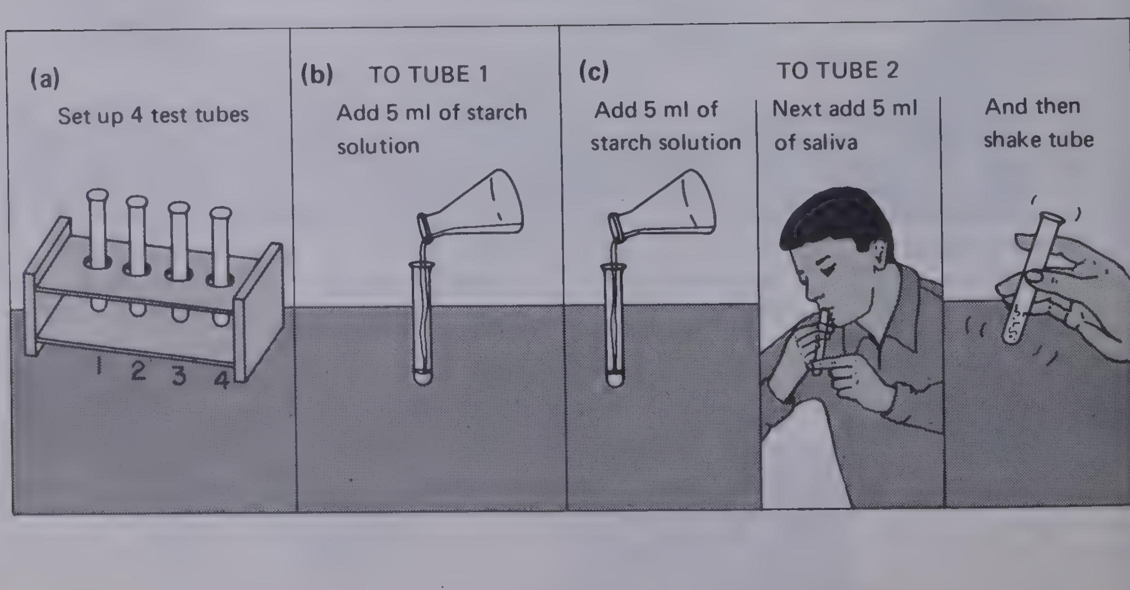
8. What does the enzyme in your saliva do to starches?

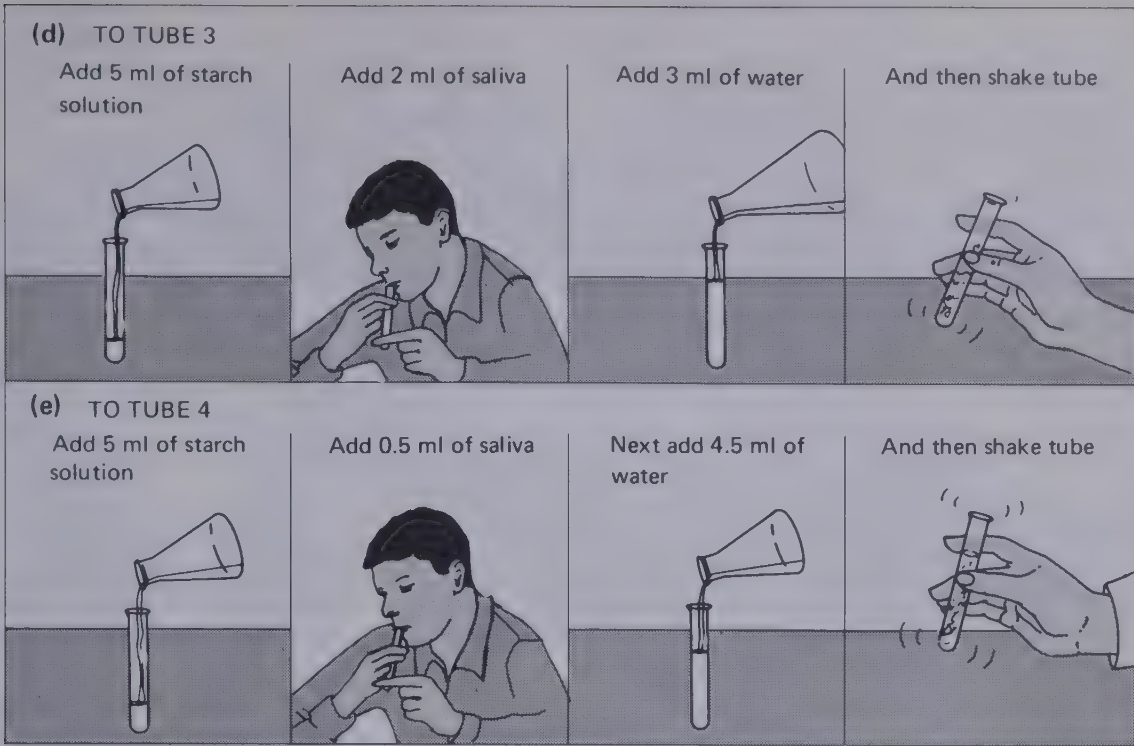
B. HOW SWEET IT IS

Now that you have some understanding of what a digestive enzyme can do to food, you will do two experiments.

Difference in Concentration: What is the effect of different concentrations of enzymes on digestion?

Place 5 ml of the prepared starch solution into each of the four test tubes. Number the tubes. Add 5 ml of saliva to tube 2. To tube 3, add 2 ml saliva and 3 ml of water. To tube 4, add 0.5 ml saliva and 4.5 ml of water. Shake each tube.





Now you have equal amounts of starch in every tube. The only difference is the amount or concentration of saliva.

Let all four tubes stand for 5-10 minutes and then test for sugar. Record your results in Table 2 of your data sheet.

9. Which tube was the control?

10. Did the control show any sugar? Why?

11. How much sugar did the other tubes show?

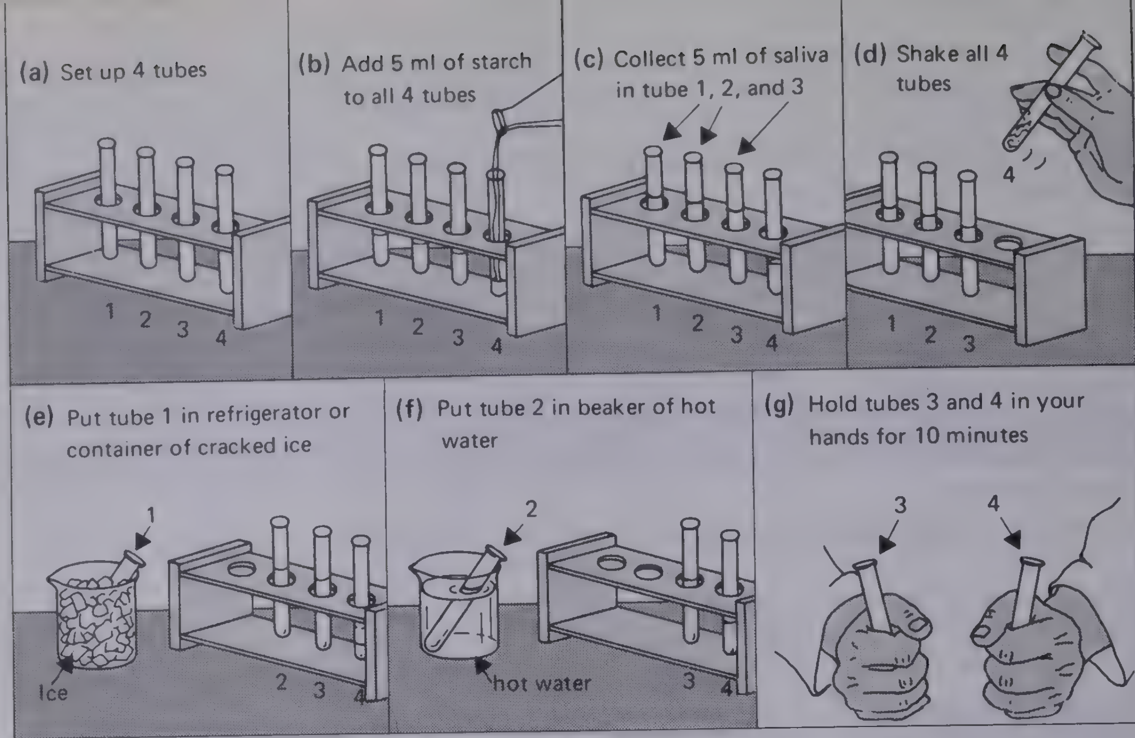
12. How would you explain the results of your experiment?

13. What do you think would happen if your body did not produce enough enzymes?

As food is moved through the digestive system, it is pushed, squeezed, and shoved around. Your mouth crushes and chops up the food. The food in your stomach is squeezed for nearly an hour by powerful muscles, and is changed to an almost liquid condition.

The 20-foot tube extending from your stomach is called the small intestine. For 3-4 hours, about 10 different kinds of enzymes break down the food, changing it to a size that can be used by your body cells.

Difference in Temperature: What is the effect of different temperatures on the action of enzymes?



Set up four test tubes and number them. Place 5 ml of the prepared starch solution in each of the four tubes. Add 5 ml of saliva to tubes 1, 2, and 3. Add 5 ml of water to tube 4.

Immediately put tube 1 in a refrigerator or a container of crushed ice. Put tube 2 in a hot water bath. Keep tube 3 and tube 4 at room temperature. After ten minutes, test all four tubes for the presence of sugar. Record your findings in Table 3 of your data sheet.

14. Which tube was the control?

15. Which tubes showed the presence of sugar?

16. How would you explain the results of your experiment?

17. What kind of temperature is needed for a digestive enzyme to work properly?

18. As far as digestion is concerned, why is it important that your body maintain its balance temperature?

C. WORKING TOGETHER ISN'T ENOUGH

In the last investigation, you learned that various processes in your body operate together. You have just seen it again in this investigation. The temperature of the body, the amount of enzyme released, and all 30 feet of the digestive system must work together.

19. But to digest food efficiently, the temperature and amount of enzyme should be at a ___?___

20. Likewise, every process that functions in your body operates best at its ___?___

CONCEPT SUMMARY.

Investigation 7

A Real Moving Story

Would it astonish you to know that the average teen-ager eats his own weight in food every month? If you eat your weight in food every month, why don't you double your weight every month? Where does all the food go?

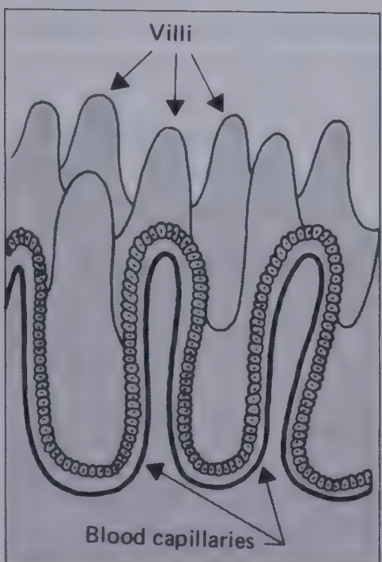
"I Guess It's Time to Take You Off Your Diet!"

In the last investigation, you learned that food is broken down by certain chemicals called enzymes. In about four hours, whatever you eat is reduced to a thin liquid inside your small intestine. What happens to this liquid?

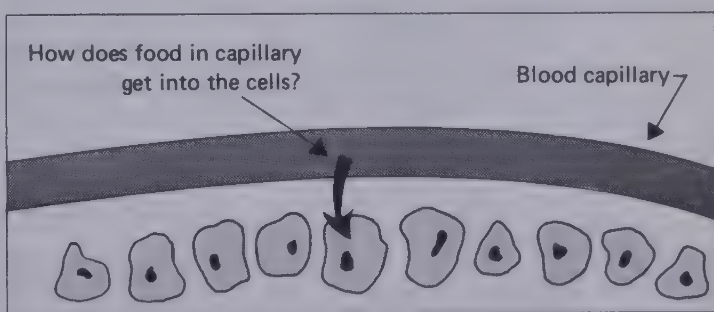
A. HARD-BOILED EGGS AND STRAWS

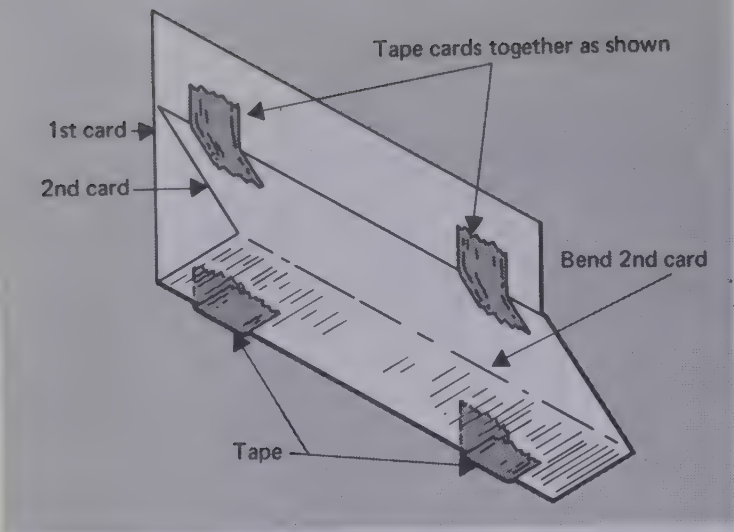
All of the food materials needed to keep you alive are found dissolved in the liquid in your intestine. These materials must somehow leave the intestine and reach every cell in the body.

The inside wall of the small intestine is lined with many little fingerlike projections called *villi*. Inside each of these villi are capillaries. (You may remember that blood carries dissolved food to all the body cells.) How does the liquid pass through the walls of the villi and into the capillaries? Then, if the liquid food gets into the capillaries, how does it leave the capillaries and get into the cells?



Villi in the Small Intestine



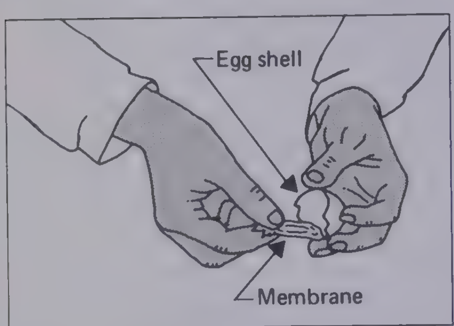


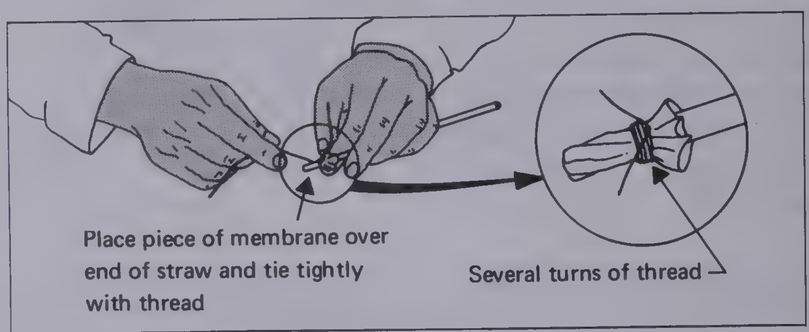
In this investigation, we will see how liquids pass through and into cells. Begin by folding a 3" x 5" card and taping it to another 3" x 5" card, as shown.

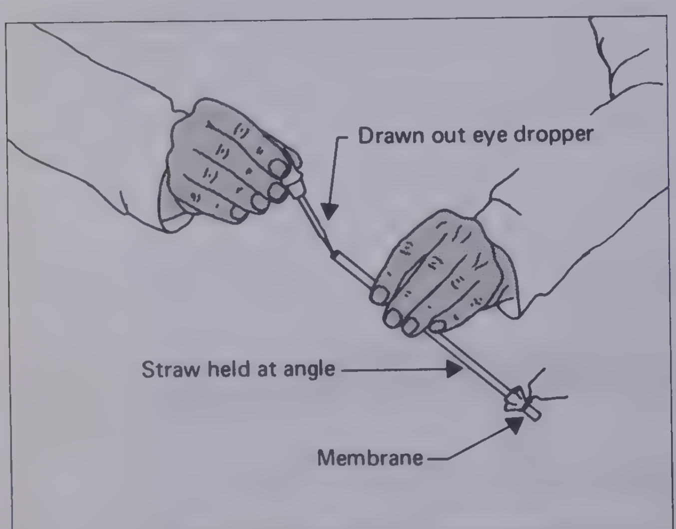
You have probably noticed a thin white "skin" under the shell of a hard-boiled egg. This "skin" is called a *membrane*. Each of the cells in your body is surrounded by a membrane which holds the cell together. Membranes have other jobs, too. Let's work with some membranes to see what they do.

You will need four clear plastic straws, some tape, thread, and eggshells. Cut the straws into lengths of about three inches.

Carefully peel some large pieces of membrane from an eggshell. The membrane comes off more easily if the shell has been allowed to dry. Tie a big piece of egg membrane over one end of each of your straws. Be careful not to tear the membrane where it covers the straw. Wind the thread tightly around the straw several times and then tie it.







Now use an eyedropper to put a different liquid inside each straw. You cannot rush this part, so don't try to hurry. Hold the straw at an angle so that the liquid flows down the side. This will keep air bubbles from being trapped in the straw.

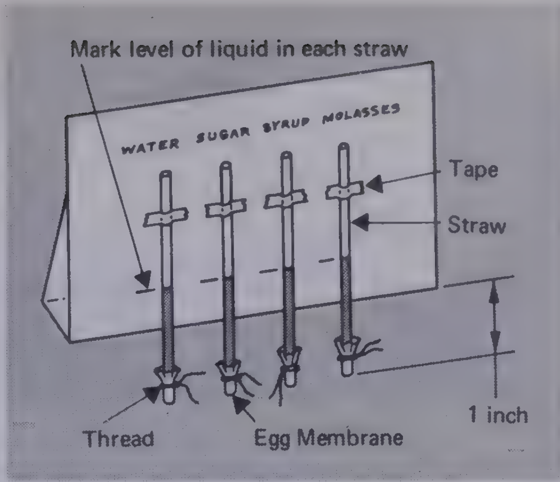
Fill each straw half full with one of the following solutions:

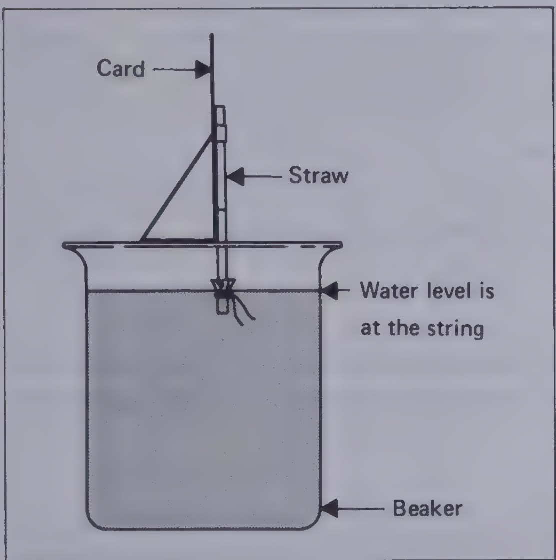
a. Water
b. Sugar solution
c. Corn or maple syrup
d. Molasses

If any of the liquid drips on the outside of the straw, clean it immediately.

Tape your straws to the 3" x 5" card so that the bottoms extend about 1" below the card, as shown. Mark the level of the liquid in each straw on the card.

Set the straws and the card in a beaker. Slowly add water to the beaker until the water reaches the strings tying the egg membranes. Let the straws sit overnight. The next day record any changes in your setup in Table 1 of your data sheet.





1. Which straw was the control?

2. Were there any straws that showed no change? Which ones?

3. Which straws showed a change?

4. Taste some of the water in the beaker by dipping your finger in and then licking it. Does it have a sweet taste? Explain.

5. If the amount of liquid in any of the straws increased, how do you think this happened?

6. What do you predict the membrane can do?

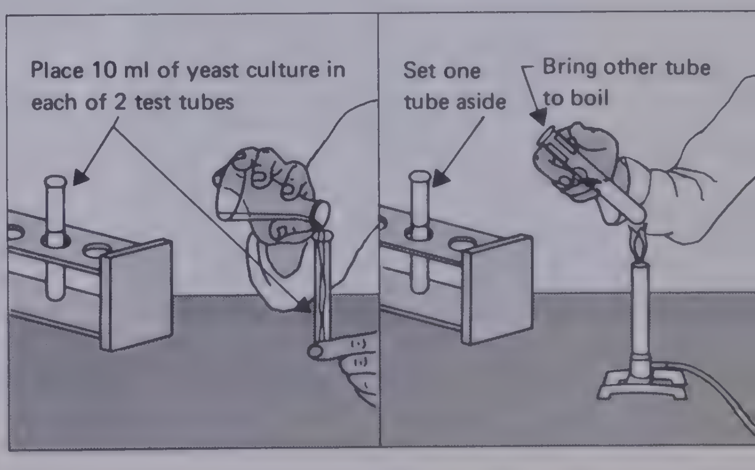
B. HARD-BOILED YEAST AND DYE

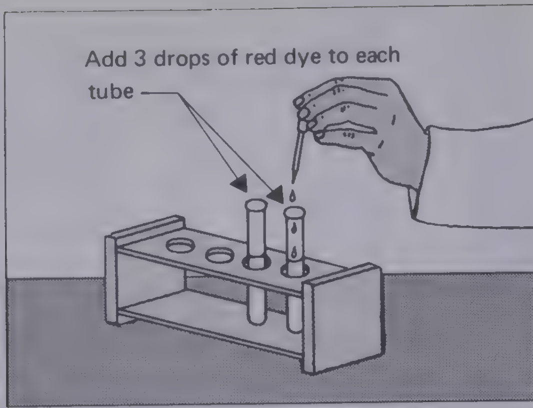
It seems that the membrane controls what can pass in and out of a cell. The following experiment should give us some data to see if this is true.

Place one drop of yeast culture on a slide. Place a cover slip over it. Observe the yeast under the high power of your microscope. In space *a* of your data sheet, make a drawing of what you see.

Place 10 ml of yeast culture in each of two test tubes. Set one tube aside. Heat the other tube to boiling. Do not allow the liquid to boil over.

CAUTION: DO NOT POINT THE TEST TUBE AT ANYONE WHEN YOU ARE HEATING IT. HOLD THE TUBE AT AN ANGLE.





Add three drops of red dye to each tube. Observe one drop of liquid from each tube under high power. Make a drawing of what you see in spaces *b* and *c*. Draw the boiled yeast in space *b*, the unboiled yeast in space *c*.

7. Was the red dye outside or inside the yeast cells that had *not* been boiled?

8. Where was the red dye when you looked at the yeast cells that had been boiled?

9. What did boiling do to the yeast cells?

10. What do you think happened to the yeast cell membranes when the yeast was boiled?

11. What do you think is the role of the membrane?

12. Using what you have learned about membranes, explain your answers to "7" and "8."

C. THE SEA WITHIN US

Three-fourths of your body weight is water. The water is slightly salty because of the chemicals in it. This salty sea flows through every blood vessel, fills every cell, and reaches every cell membrane. No part of the body could survive without water.

In a normal day, you take in about 2½ quarts of water, mostly in the food you eat. You also excrete about 2½ quarts of water as urine and sweat. This balance helps keep your weight steady.

We also know that half of the water in your body is replaced every two weeks. The ability of your body to keep just the right amount of water is another example of homeostasis.

13. You have seen that the proper balance of water is essential to life. But the balance of the water in any living thing is controlled by the __?__

14. What is one structure that helps the body to maintain its proper internal balance?

CONCEPT SUMMARY.

Investigation 8

How's Your Blood Sugar?

In the last investigation, you learned that cell membranes help regulate the flow of materials into and out of each cell. Does your body have any other means of regulating its internal balance?

Before we answer this question, let's review two basic concepts you have studied:

a. Living things can respond to various stimuli.

b. The various body processes respond to maintain a balanced or constant state.

Every response and change in your body helps to maintain the delicate internal balance of your body. We call this delicate balance or constant state, *homeostasis*.

Although you know that living things can respond, you do not know what regulates the response. How are the responses or adjustments controlled?

"And That Is the Latest Ultrasonic Whistle!"

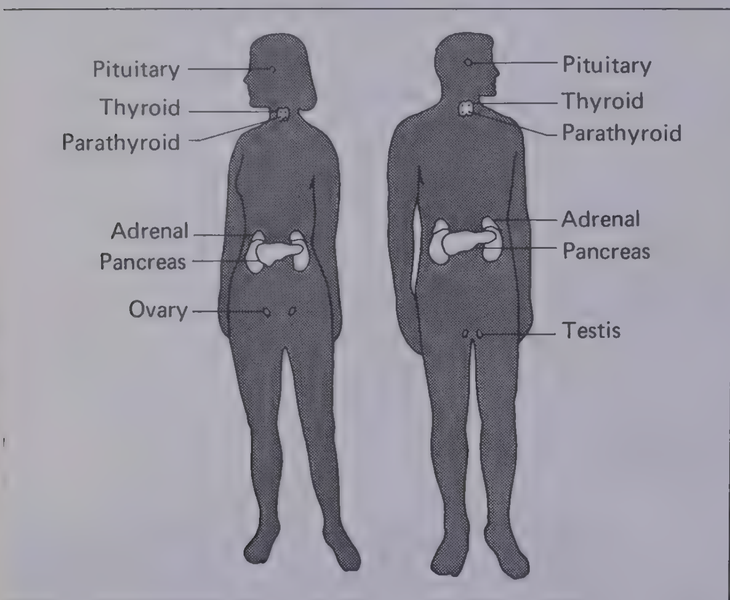
Wide World Photos

A. THERE'S A DIFFERENCE IN SIZE

You have a number of glands in your body. These glands secrete (give off) chemicals called *hormones*. The glands secrete hormones into the bloodstream, which carries them to all parts of the body. Hormones are like chemical messengers. They help regulate conditions in the body.


Syndication International

The Glands in the Human Body



Plants secrete hormones, too. For instance, the dwarf pea plant in the lower left does not make a hormone called gibberellin. The pea plant in the lower right makes gibberellin. Note the difference in size of the plants.

A Dwarf Pea Plant


Asgrow Seed Co.

Tall Pea Plant


Asgrow Seed Co.

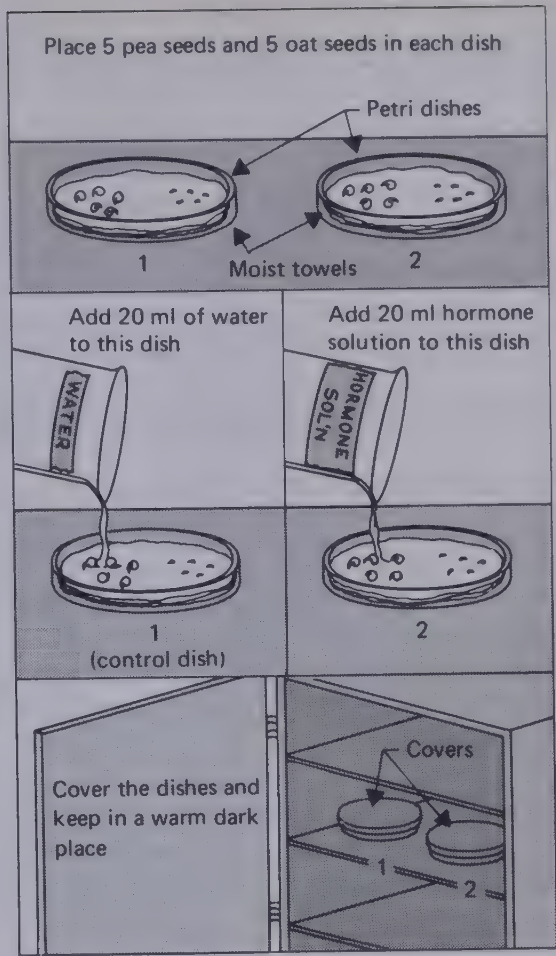
1. What do you predict would happen if plant hormones were given to some germinating seeds and not given to some others?

Line a Petri dish with 3-4 circles of paper towel. Put five pea seeds and five oat seeds in the dish. Label this dish "experimental." Repeat the procedure with a second dish. Label this dish "control." Add 20 ml of plant hormone to the experimental dish. Add 20 ml of water to the control dish.

After 4-5 days, measure the lengths of the roots of every seed. Record the data in Table 1. Calculate the average growth of the seeds.

2. Was there any difference in growth between the seeds supplied with hormones and the seeds given only water? If so, explain.

3. What do you think caused the difference in growth?



B. SOMETHING TO CROW ABOUT

You have just seen the response to a growth hormone in plants. Is animal growth also controlled by hormones?

Testosterone is a hormone secreted by the testes. Testosterone regulates the degree of maleness in an individual. The comb on a rooster's head is a sign of maleness.

4. What do you predict applications of testosterone will do to the size of a comb on a rooster?

You should work in groups of four for this experiment. Each group will be given two 1-day old cockerels. These are baby roosters or chicks. Note that the chicks have been marked so that you can get the same ones back every day.

Measure the length and height (at the highest point) of the combs of your chicks. If necessary, use scissors to clip away the feathers. Record the data in Table 2 of your data sheet.

Apply a small amount of testosterone ointment on the comb of one of the chicks. This is the experimental chick. Do not apply any testosterone on the comb of the other chick.

5. What do you call the chick that is left untreated?

Be sure to record which chick is treated and which is untreated.

On the next four days, measure the length and height of the combs and record the data in Table 2. After each daily measurement, reapply a small amount of testosterone on your experimental chick.

6. Did one comb grow faster than the other? If so, which one?

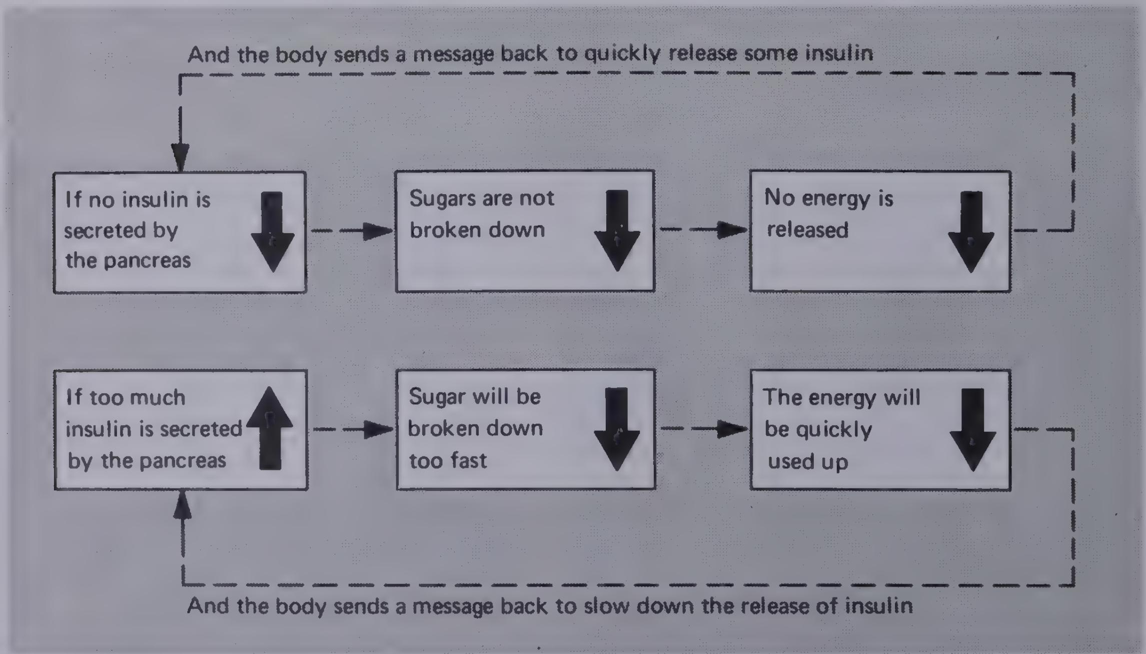
7. What do you think caused one of the combs to grow faster?

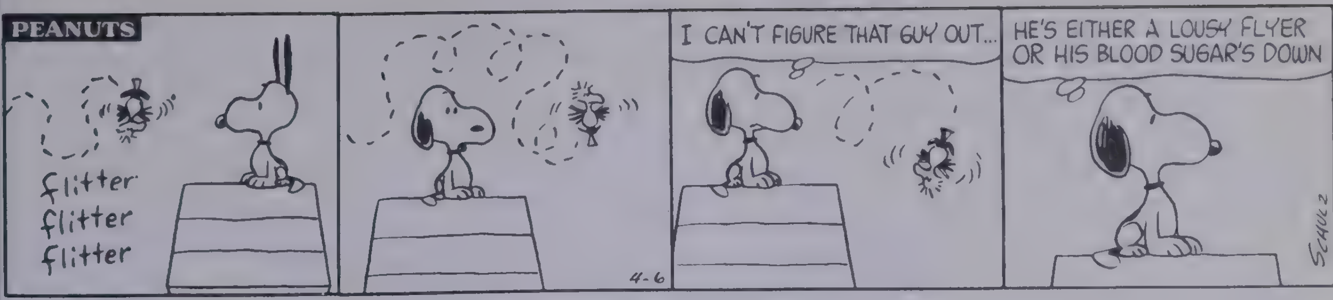
C. JUST THE RIGHT AMOUNT

Just the right amount of hormone must be present to maintain a balance. If too much or too little is used, the wrong reaction can occur. Let's consider the hormone called insulin.

Insulin is secreted in your body by the pancreas gland. Insulin is needed to break down the sugar in the food you eat. When sugar is broken apart, energy is released. This energy keeps you alive.

If too little insulin is secreted, you do not break down enough sugar. You will be short on needed energy. If too much insulin is secreted, you will quickly burn up all the sugar you eat. All the energy is released in a short period of time, and you will either have to eat again or collapse from the lack of energy.





There are many people who do not secrete enough insulin. These people suffer from a disease called *diabetes*. Diabetes can be corrected by injections of insulin.

For many generations, man looked upon germs—bacteria and viruses—as the prime culprit in human diseases. Now it appears that many diseases may be based not on attack from the outside by germs, but on the failure of delicate regulating devices inside the body.

The more we study humans, the more we find that the human body has a great capacity to readjust its complex machinery. Man is indeed a very delicately balanced organism.

8. In the last investigation, you learned that a regulating device surrounds every cell. This structure is called the ___?___

9. In this investigation, you have learned that the body has another regulating device in the form of special chemicals called ___?___

10. What do hormones help the body to do?

CONCEPT SUMMARY.

Investigation 9

What's This Scene All About?

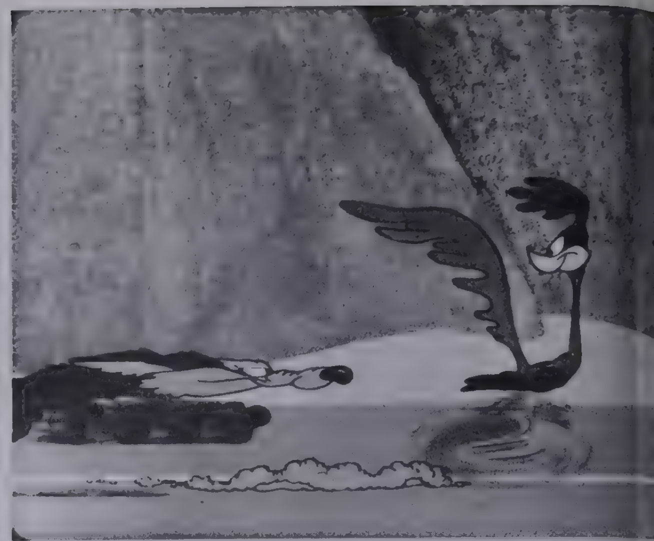
Your body is full of separate balancing devices which maintain homeostasis. You have seen that they balance the pulse rate, the breathing rate, the amount of hormone secreted, and the rate at which chemicals pass through a membrane. How does your body keep everything at a constant state?

You have a nervous system with five major sense organs. Each of these organs has nerves which receive messages from various *stimuli*.

All of the body processes are controlled by the master coordinator of the body, the brain. The brain is the *interpreter*. It makes decisions about what to do with the messages coming from the sense organs or *receivers*.

The glands, bones, and muscles are the *effectors*. They do work which causes a *response*.

Warner Brothers



Warner Brothers

Here is an example:

Danger	(stimulus)
is seen by the eye;	(receiver)
the message is sent to the brain,	(interpreter)
which signals the muscles and bones	(effector)
to move.	(response)

If all the steps are carried out, the body quickly returns to a balanced or constant state. If the body does not react, then trouble is ahead.

A. A REAL BAD TRIP

There are some who believe that certain drugs can increase self-awareness, or sharpen the senses. They believe that drugs which affect the nervous system can broaden the powers of the mind. On the other hand, there are some who feel these drugs are harmful, with little or no value.

If the nervous system is essential in helping the body maintain homeostasis, what happens when it is affected by drugs? And what happens if the nervous system goes on a "bad trip"?

"C'mon Man! Drop a little acid! Everybody's turning-on! Let's get stoned!" That's the big drug scene. What's it all about?

To begin, let's understand what we are talking about. Drugs affecting the nervous system are often prescribed by doctors to restore a balanced state in the body, when homeostasis has been upset by illness or an accident. The same drugs, however, can be *abused,* that is, used to upset the balanced state of the body. There are three major types of drugs presently being abused.

Stimulants: Called "speed," "dexies," "pep pills," "bennies," and other names, they are usually a drug called amphetamine. This drug acts directly to stimulate the nervous system and produces a feeling of excitement and energy, the ability to stay awake, and loss of appetite.

While under the effect of the drug, the user may show signs of restlessness, nervousness, dryness of the mouth, and heavy perspiration. He may "black out" from having used up too much energy. The increased activity may cause reckless behavior, such as driving too fast, talking excessively, and having delusions.

There are data to show that an overdose, or repeated dosages, of amphetamines can cause a person to lose contact with what is happening around him. Doctors call this condition *psychosis* and it is a form of temporary insanity. Amphetamines are especially dangerous because they are definitely addictive.

dpi

Stimulants and Depressants

Depressants: Referred to as "barbs," "yellow jackets," "peace pills," "downers," and so forth, they are usually barbiturates or tranquilizers. Depressants are the opposite of stimulants. They depress the nervous system to relieve tension or produce sleep.

The abuser of depressants will exhibit signs of drunkenness. Barbiturates and alcohol taken together have caused accidental death.

Depressants may make a person less alert and slower to react. Increased amounts cause sluggishness, depression, and even a quarrelsome disposition. The tongue may thicken and speech slur because of a loss of physical coordination. Mental and emotional instability may result and the user may slump into a deep sleep or coma.

Hallucinogens: Commonly called "pot," "grass," "acid," "cubes," and "trips," the hallucinogenic drugs have been promoted as a way of expanding the mind.

The drugs are called hallucinogens because they cause hallucinations. These are feelings of a dream world in which the senses become distorted and more intense. The effects on the mind are unpredictable and may include illusions, pain, impulsive acts, violence, and self-destruction.

The two most common hallucinogens are marijuana and LSD.

Richard Lawrence Stack from Black Star

Marijuana

Paper Containing LSD

From Black Star

Marijuana has no known medical uses. While marijuana is not addictive, it can be habit-forming. There is some evidence that those who are heavy users of marijuana become very passive and apathetic. A severe overdose of marijuana can cause a coma.

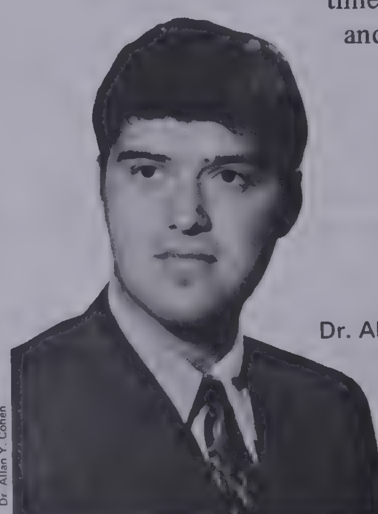
LSD has been advertised as a drug which can increase a person's self-awareness and creativity. There are no controlled experiments to prove these claims. On the other hand, there is evidence to show that some people have serious and powerful adverse reactions to LSD. The most serious adverse reactions are panic and deep depression, leading to mental breakdown and suicide.

There is strong evidence that continued use of LSD causes a person to be more passive, less ambitious, and more willing to "drop out." At present, scientists are investigating the possibility that LSD may cause brain damage, chromosome damage, and cancer of the blood (leukemia).

What's a teenager to do nowadays? The come-on is strong and inviting. The temptation to be "in" is great.

"The Establishment is always saying LSD is harmful. What do they know about it?"

Dr. Allan Y. Cohen worked at Harvard University in drug research. He took LSD 30 times during that period and has since stopped. He is presently teaching at John F. Kennedy University in California. He says:



Dr. Allan Y. Cohen

Dr. Allan Y. Cohen

"LSD is a fake. All it does is inflate the ego. LSD creates self-delusion. Then there is dependency. The LSD ethics says you cannot be high unless you take a chemical. That is not freedom, or fun; that's slavery.

"I found out that LSD does not make better people. There was still laziness, arguments, lack of consideration, and fear. Just hours after a trip, we'd fight over who should do the dishes.

"I tuned in, turned on, and dropped out, but after using LSD for three years, I stopped. I did not live any more of a spiritual life than those people who did not take LSD."

You have just read some comments about taking drugs. Perhaps you have other comments or don't agree with the comments here. Perhaps you know of other arguments for and against using drugs.

Survey your classmates, friends, family, neighbors, doctors, and policemen. What are their stands?

1. List additional arguments *for* taking drugs. Comment on each.

2. List additional arguments *against* taking drugs. Comment on each.

Now you've heard from both sides. What you do with your life is up to you. In a few short years, you will be the establishment. What you do or don't do will be your bag.

Eugene Anthony from Black Star

B. NOT THE END, BUT A REAL BEGINNING

A balanced or constant state has been the theme running through all of these past investigations. We call the maintenance of the body at a constant state *homeostasis.*

3. The three groups of drugs discussed in this investigation act mainly on what system of the body?

4. The purpose of this investigation has been to show you that drugs can upset what system of the body?

5. If this system is upset, then homeostasis is upset. What system coordinates all of the life functions necessary to maintain a constant state?

Use your answer to question 5 to complete your concept summary.

CONCEPT SUMMARY.

Investigation 10

The Game of Homeostasis

A yellow-bellied sapsucker, a porcupine, and a human being may look different, but they all have certain characteristics of life that are similar.

Yellow-bellied Sapsucker

Allan D. Cruickshank from National Audubon Society

Porcupine

Leonard Lee Rue III from Monkmeyer Press Photo Service

They:

a. can respond to a stimulus.

b. can respond in different ways to different stimuli.

c. can respond to keep the body in a balanced or constant state.

d. have different body functions which operate best at certain balanced states.

e. have cell membranes which help the body to regulate its balanced state.

Canadian Consulate General

f. use hormones to help the body regulate and maintain its constant state.

g. have a nervous system which coordinates all the life functions necessary to maintain a constant state.

These are the major concepts you have learned from the past nine investigations in *Homeostasis.* If you have learned the meaning of homeostasis, proceed immediately to write the IDEA Summary.

The next section will treat you to a groovy, in-gear, gassy, outta-site, un-hung-up, wild, tuned-in, cool, turned-on game—which will also summarize this Idea.

A. LET'S PUT THE PIECES TOGETHER

At one time it was thought that the average teen-ager needed 3,000 calories each day. It has now been discovered that such heavy eating has resulted in a nation of overweight people.

The average person needs about 2,400 calories each day as fuel for energy. This energy is used by the various parts of the body to help maintain homeostasis. If a stimulus upsets a part of the body, it must be remedied with the correct response. This is the basis of the game *Homeostasis.*

Look at the two sheets with the word "Homeostasis" at the top. The object of the game is to be the first to place exactly 400 calories under each of the six parts of the body.

At the same time each player tries to prevent his opponent from adding calorie cards. This is done by placing upsetting stimulus cards above the appropriate body part. Then the correct response card must cover the stimulus card before calories can be added under that body part.

Procedure

1. Arrange the two pages (supplied by your teacher) in front of you to spell "Homeostasis."

2. It is recommended that 2, 3, or 4 students play. If 4 students play, play as two teams. Partners are to sit opposite each other. The two sheets mentioned in step 1 are to be placed in front of one of the partners only.

3. If a deck of Homeostasis cards is not available, glue the sheets provided by your teacher to pieces of tag board or cardboard. Cut out the individual cards.

4. Each player adds enough cards to make up the following deck of 114 cards.

BODY	STIMULUS	RESPONSE	ENERGY
Parts (2 sheets)	*Stop Cards*	*Go Cards*	*Calorie Cards*
Stomach	Ulcer (6)	Antacid (6)	300 (6)
Small Intestine	Diabetes (6)	Insulin (6)	200 (20)
Large Intestine	The Runs (6)	Camp-out (6)	100 (16)
Heart	Obesity (6)	Diet (6)	
Lung	Lung Cancer (6)	Stop Smoking (6)	
Nervous System	Bad Trip (6)	Security (6)	

5. Shuffle the cards and deal six to each player. Put the remaining cards in the middle of the table.

6. Proceed in a clockwise direction when playing.

7. Each player, beginning with the dealer, picks up a card from the pile on the table and makes a play.

8. When a card is played, there are four moves possible.

a. Add a calorie card under any of your own body parts.

b. Place a stimulus card above any of the body parts of your opponent.

c. Place a response card on top of a stimulus card to balance the upsetting condition.

d. Discard a card next to the pile on the table.

9. All cards played are to be face up. Arrange the calorie cards so that everyone can see the totals played.

10. The object of the game is to be the first to put down *exactly* 400 calories under each of your own body parts. (This will add up to the daily requirement of 2,400 calories.) As each set of 400 calories is reached, turn those cards upside down to cover the body part.

11. You can stop the opposing team temporarily by placing an upsetting stimulus card above the appropriate body part. The opposing team must respond with the correct response card before they can continue to add calorie cards under the appropriate body parts.

12. The response card should be placed on top of the upsetting stimulus card.

13. If you are the first to reach 2,400 calories, call "Homeostasis."

14. If the entire pile on the table is exhausted and no one has reached 2,400 calories, shuffle the cards in the discard pile and continue.

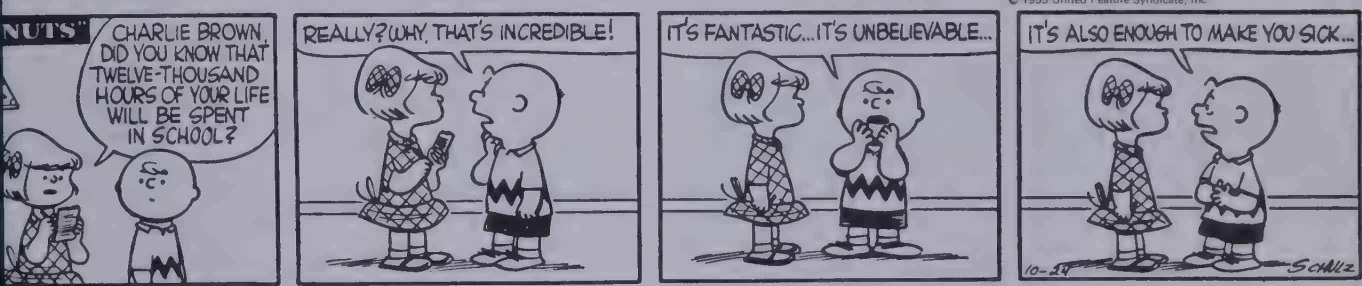
If you have not already done so, state the idea of homeostasis in the IDEA Summary.

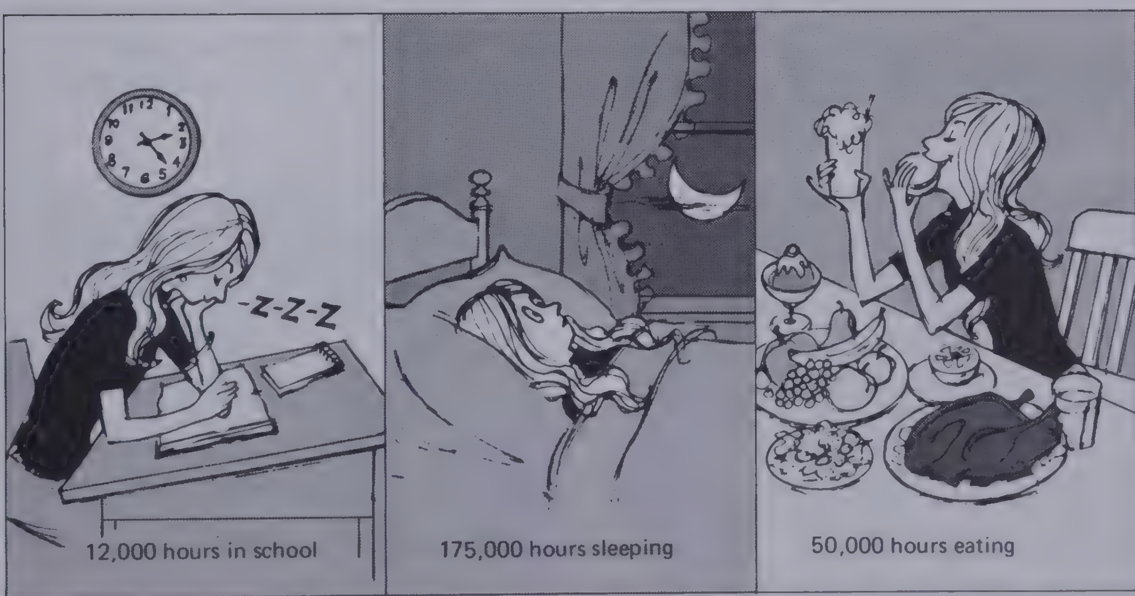
Idea 5
Ecology

Investigation 1

You Eat Nearly a Ton of Food

Did you know that about 12,000 hours of your life will be spent in school, 175,000 hours in sleeping, and 50,000 hours in eating?





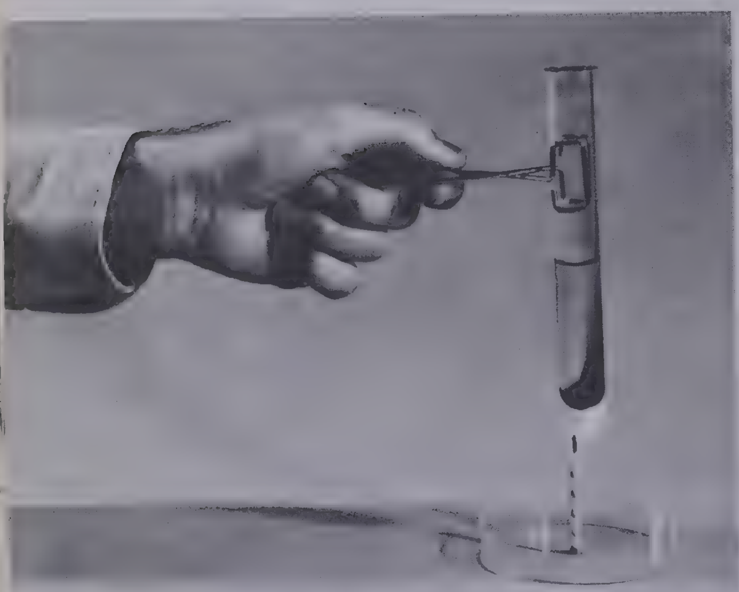
12,000 hours in school | 175,000 hours sleeping | 50,000 hours eating

Statisticians at the Department of Agriculture have determined what an average person eats in a year: 181.5 pounds of meat, 19.7 pounds of fish, 318 eggs, 36.4 pounds of chicken, 279 pounds of milk and cream, 18.5 pounds of ice cream, 77.3 pounds of fresh fruit, 23.1 pounds of canned fruit, 95.1 pounds of fresh vegetables, 49.2 pounds of canned vegetables, 118 pounds of potatoes, 98 pounds of sugar, 109 pounds of wheat flour (mostly bread products), and many other food products that add up to nearly a ton of food a year.

You learned in Idea 4–*Homeostasis*–that most of the food you eat is digested in the small intestine. The process of digestion breaks down the food to particles small enough to pass through the cell membranes. The food passes from the small intestine into the bloodstream where it is carried to all the cells in your body.

This brings us to the major question for this investigation: Why do cells need food?

This also raises the major question for the entire Idea: What do all living things need constantly? Why?



A. A BURNING SENSATION

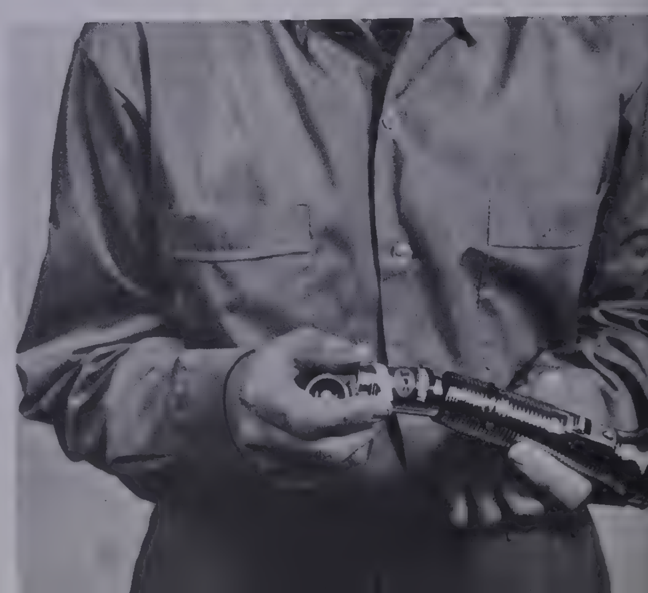
If you hold a candle under a container of water, the water will get warmer.

If you burn gasoline in a car, the car engine will run.

If you put batteries in a flashlight, the light will shine.

All three–the candle, gasoline, and batteries–have something in common. When they are used, they produce work. In other words, they can provide energy. *Energy* is the ability to do work.

Mobil Oil Corp.



Where does energy come from? To answer this question, let's take a common food—nuts. Can you get a peanut to do work for you? How?

Before you try the peanut, you will need a standard for a control. You can use a birthday candle for your control. Proceed as follows and record your data in Table 1 of your data sheet.

a. Weigh an unburned candle. Record the weight in Table 1.

b. Place the candle upright in a bit of clay on a ringstand base.

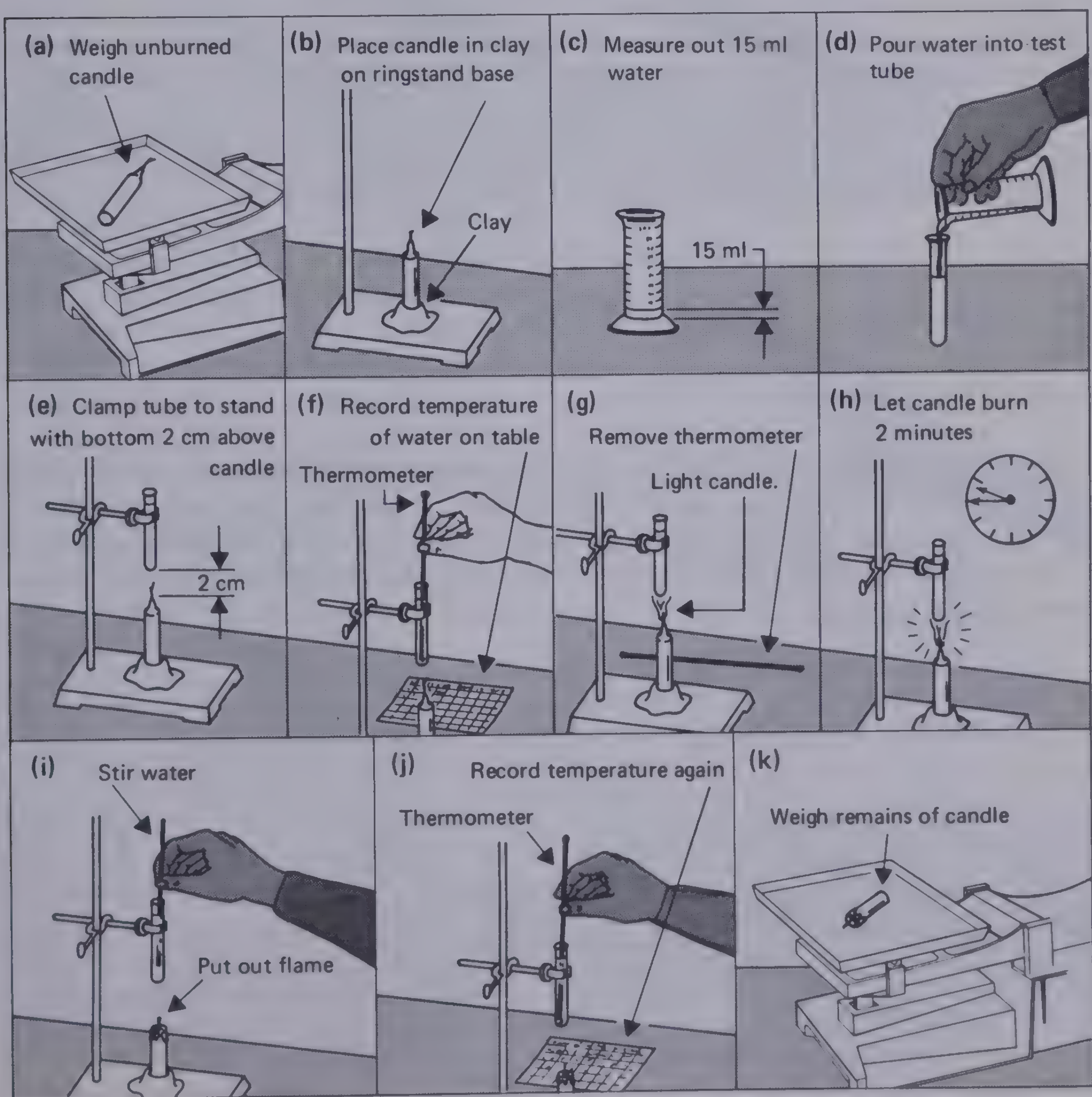
c. Fill a test tube with 15 ml water and clamp, as pictured, 2 cm above the candle.

d. Record the temperature of the water and remove the thermometer.

e. Light the candle and allow it to burn for 2 minutes.

f. Stir the water and record the temperature.

g. Weigh the remains of the burned candle.



h. To complete the last three columns of your table, find out how much the water temperature changed by subtracting the starting temperature from the final temperature:

(f) final temperature

— (d) starting temperature

(h) temperature change

i. Find out how much of the candle was burned by subtracting the weight of the burned candle from the weight of the unburned candle:

(a) unburned candle

— (g) burned candle

(i) amount of candle burned

For the purpose of this investigation, we are going to create our own standard unit. It will be called a *Candle Calorie*. This is simply the energy supplied by one birthday candle to 15 ml of water for 2 minutes. It will be our unit of energy.

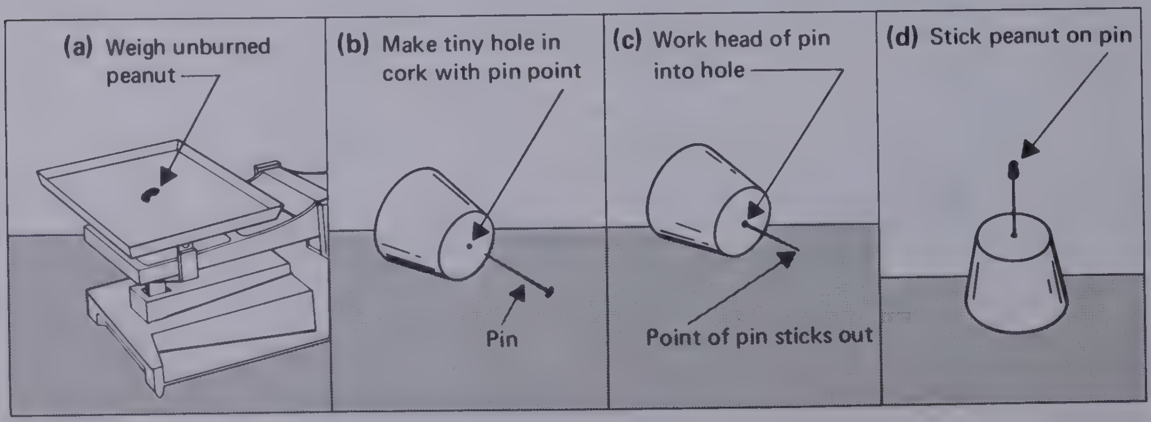
j. Find out what the Candle Calories of your candle are by dividing:

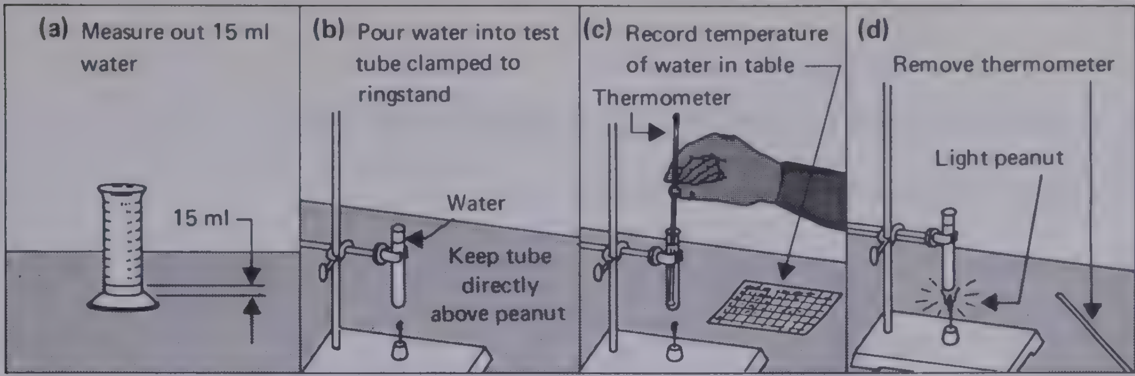
(h) temperature change of the water

(i) amount of candle burned

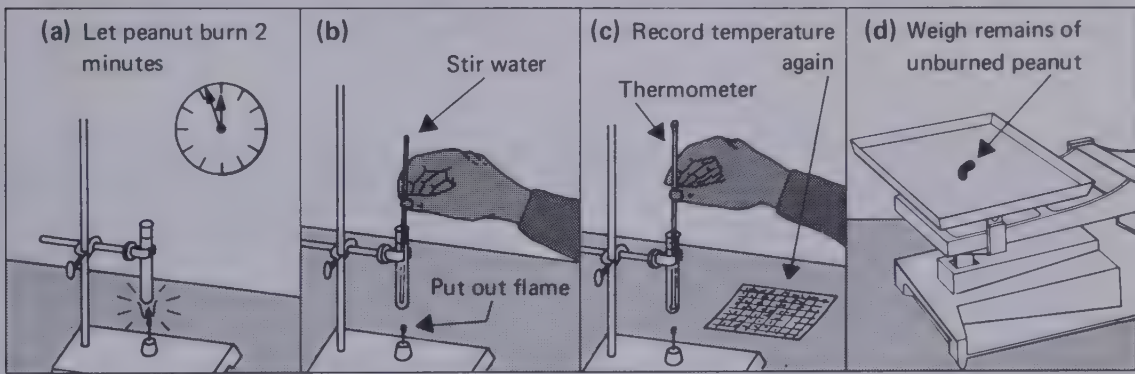
B. A NUTTY HAPPENING

Repeat the same procedure used in part A, substituting a peanut in place of the candle. After you weigh the peanut, mount it on a pin that has been stuck into a cork. Light the peanut with a match or the candle flame. If you dip the nut in some ashes, it will burn more easily. Keep the burning peanut directly under the test tube for maximum heat transfer.





Be sure to burn the peanut for the same length of time you burned the candle–2 minutes. Record all of your data in Table 1.

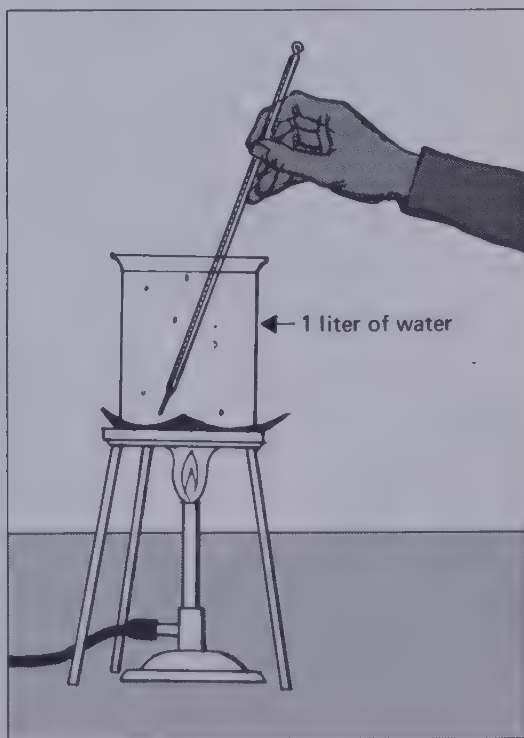


Your teacher will ask you to test the energy output or Candle Calorie of other kinds of food. Record these data in Table 1, too.

1. Which kind of food produced the most Candle Calories?

2. The Candle Calorie is really a bundle or unit of __?__

3. According to your data, you can say that different kinds of food can produce different amounts of __?__



C. STOP EATING YOURSELF TO DEATH

What is a Calorie? If you take one liter of water and heat it to raise the temperature 1°C, you will have produced 1 Calorie of energy. Heat can do work. It is a form of energy. You discovered this when you took the temperature of the water before and after the different foods were burned.

4. In order for a candle to release its energy, what must it do?

5. What must be done to get energy from gasoline?

6. What do you think a cell must do to release energy from the food it receives?

7. What do foods supply?

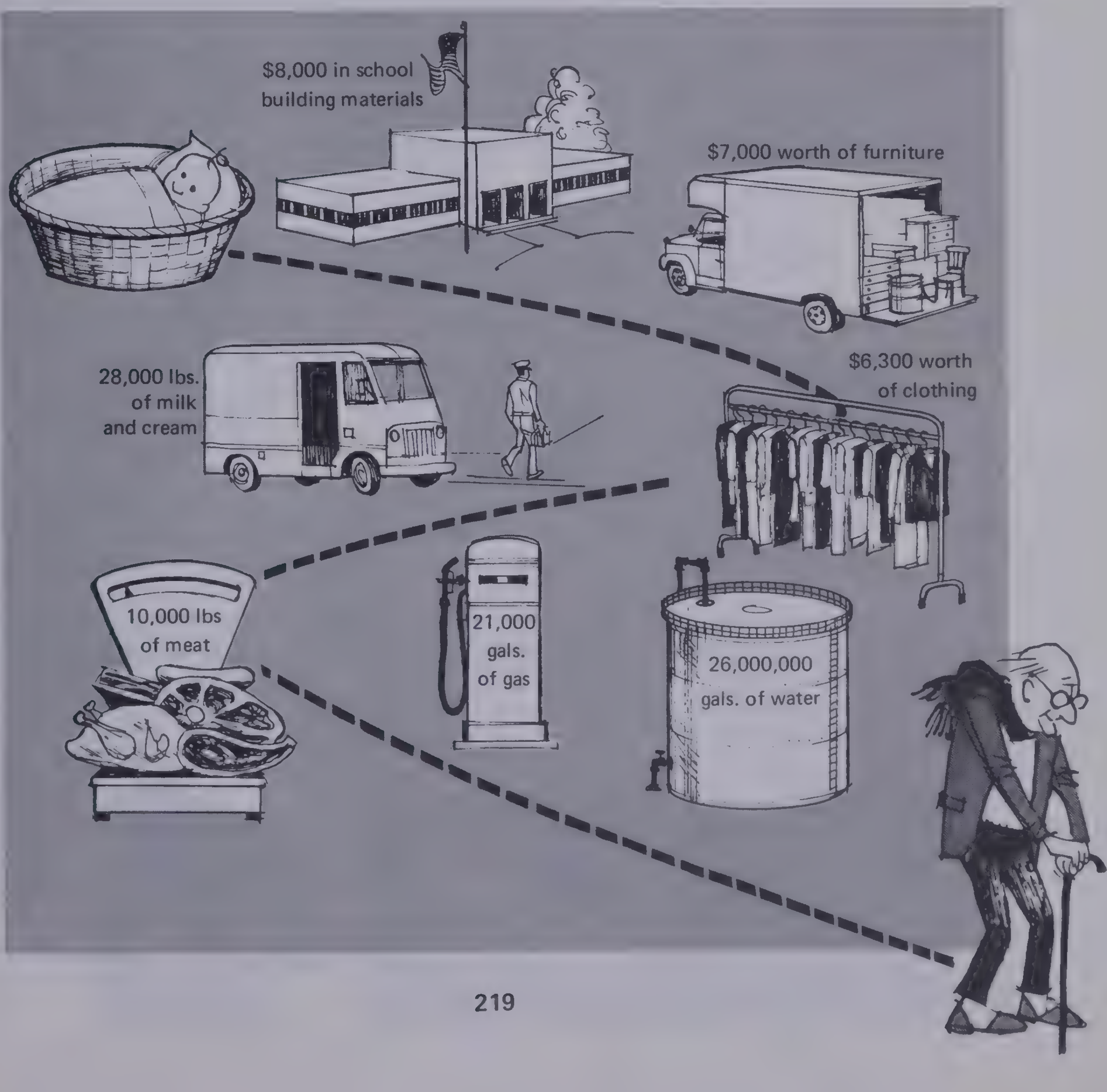
8. Name one thing all living things constantly need to live.

CONCEPT SUMMARY. (What general concept have you learned in this investigation?)

Investigation 2

A Story That's Full of Holes

Every time you breathe, three more babies are added to the Earth's population. The average American baby will be a super consumer of energy. During his life span of 70 or 80 years, he will need such things as 26 million gallons of water, 21,000 gallons of gasoline, 10,000 pounds of meat, 28,000 pounds of milk and cream, $6,300 worth of clothing, $7,000 worth of furniture, and $5,000-$8,000 in school building materials. Where will all of this energy come from? Will these products always be available?



Union Pacific Railroad Photo

We are using four times as much water per person now as compared to 1900. The water supply, however, has stayed at the same level.

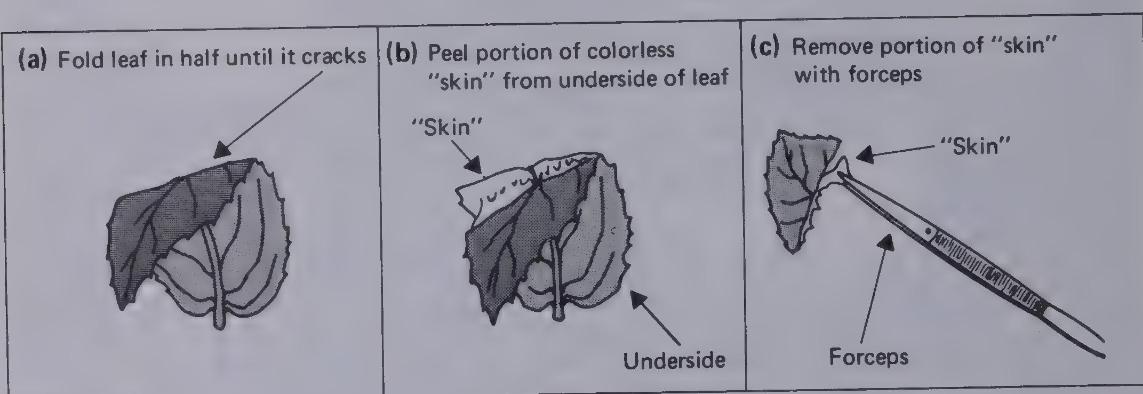
The supply of gasoline is not expected to last the life span of your children. Clothing, furniture, and school building materials will come from fewer and fewer plants because we are urbanizing 3,000 acres a day.

Meat, milk, and cream come from animals which feed on green plants for food. Therefore, the source of all the food you eat is green plants. How do green plants get their energy?

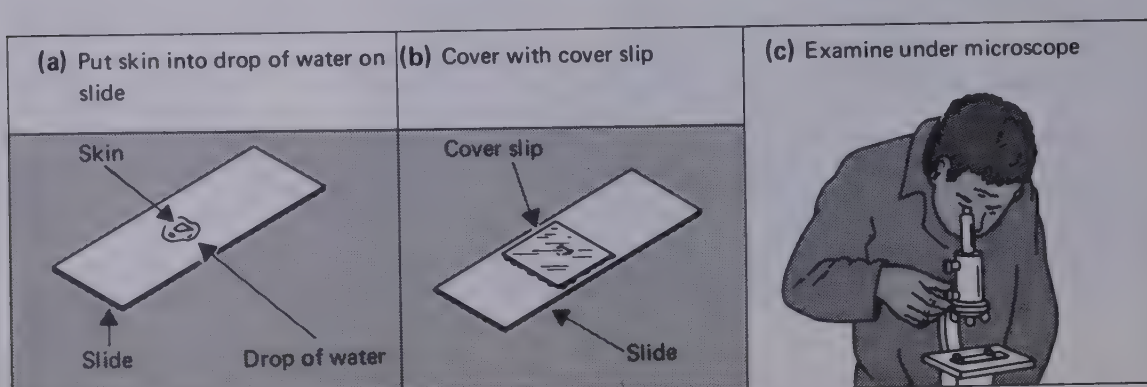
A. DO LEAVES HAVE HOLES?

The next three investigations will be concerned with how plants obtain energy. First, how do gases enter and leave a plant? You will find out by examining part of a leaf under a microscope.

Take a leaf and fold it in half. Don't worry if it cracks. Tear the leaf as shown in the diagram so that a portion of the lower "skin" appears as a narrow, colorless border along the torn edge.



Carefully remove a portion of the "skin" with a pair of forceps. Immediately place it in a drop of water on a slide. Do not allow the fragment to dry out. Cover it with a cover slip.



Examine the leaf "skin" under a microscope, and look for structures that resemble a pair of lips. In space *a* of your data sheet make a drawing of what you see.

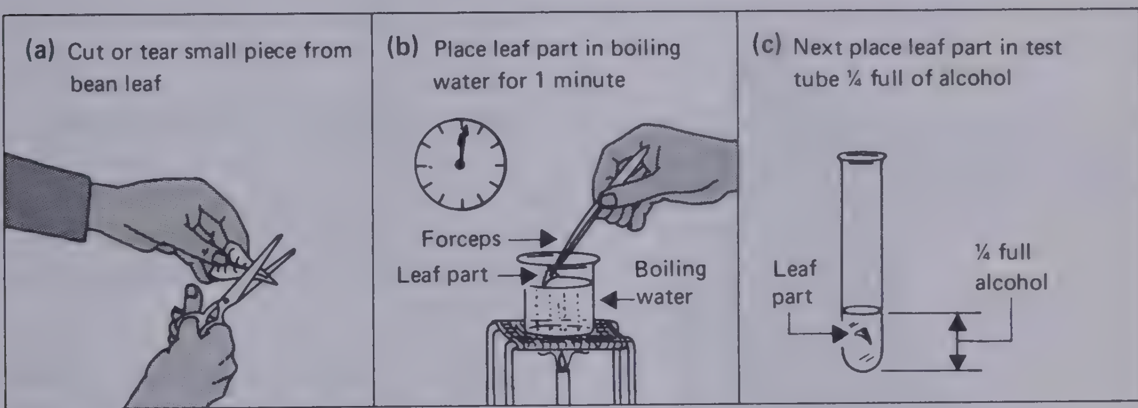
The structures that you have just observed are called guard cells. The openings in the guard cells are called the stomates. One opening is called a stoma.

1. What do you predict is the function of the stomates?

B. THE JOLLY GREEN BEAN

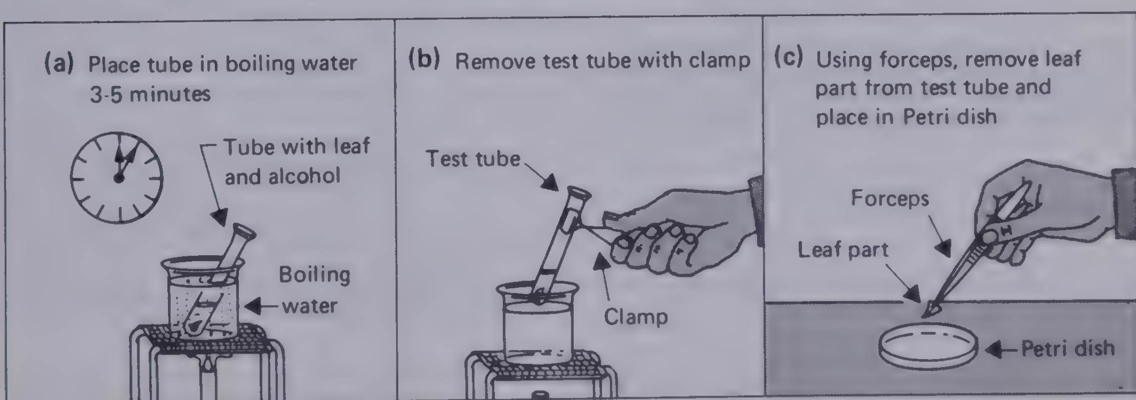
You will be shown a 3-4 week old bean plant. The plant has been given only water and sunlight. We will call this untreated plant our control.

Cut a small piece from one of the bean leaves. Using forceps, place your leaf part in a beaker of boiling water for one minute. Transfer the leaf part to a test tube ¼ full of methyl or ethyl alcohol. Place the test tube in a beaker of boiling water.

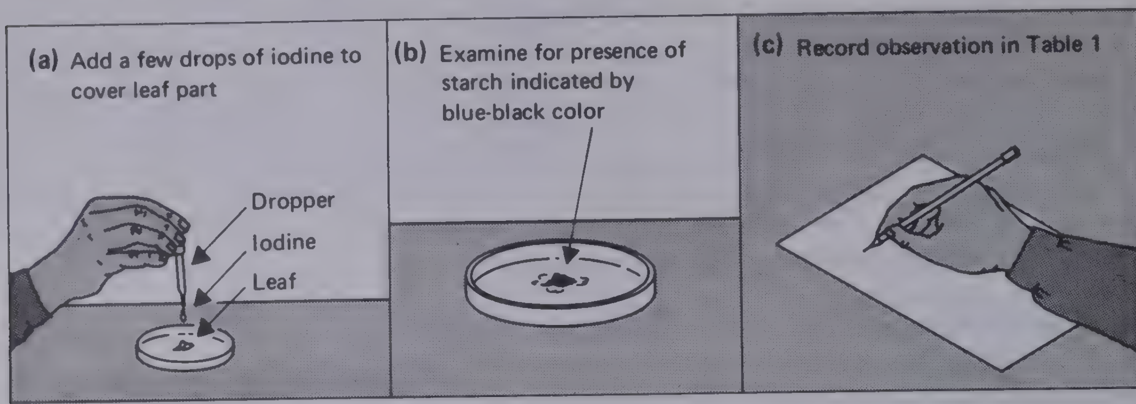


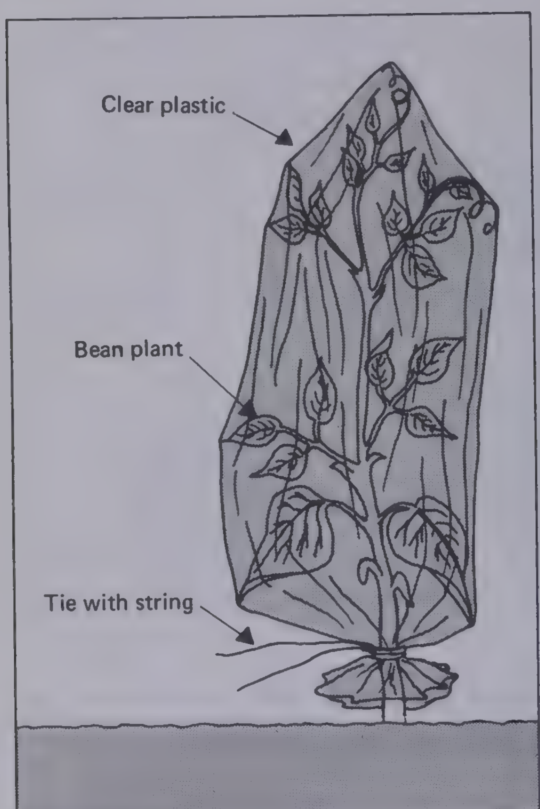
CAUTION: DO NOT HEAT THE ALCOHOL DIRECTLY.

The alcohol will take the green color out of the leaf part in 3-5 minutes. When the leaf part is no longer green, remove the test tube from the boiling water. Use forceps to place the leaf part in a Petri dish.



Add a few drops of iodine solution to cover the leaf part. Iodine is used to test for starch. A blue-black color indicates the presence of starch. Does your control leaf show a positive test for starch? Record your observation in Table 1 of your data sheet.





C. THE NOT-SO-JOLLY GREEN BEAN

Your teacher will show you another bean plant. The leaves on this plant have been smeared with petroleum jelly or covered with a plastic wrap.

2. What do you predict the petroleum jelly or plastic wrap will prevent from entering the leaves?

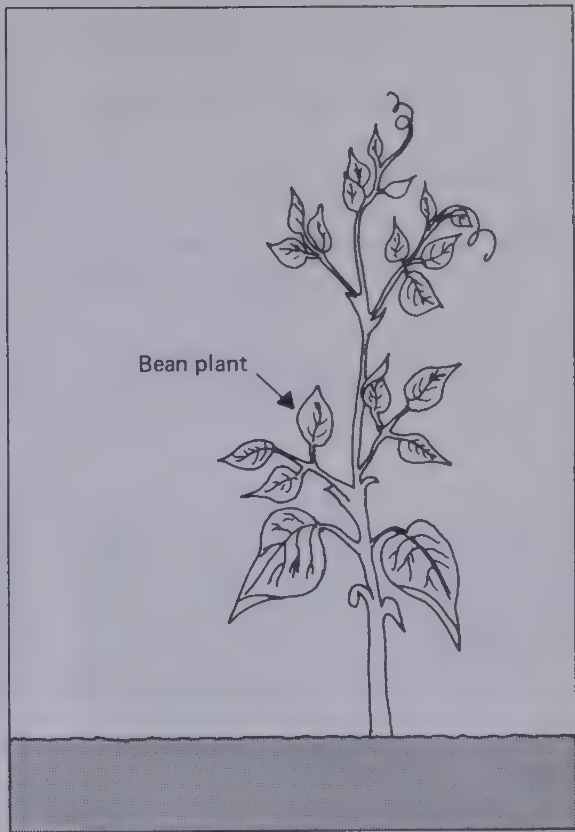
Cut a small piece from one of the leaves on this bean plant. Gently remove the petroleum jelly or the plastic wrap. Repeat the procedure in part B with this piece of leaf. Record the result of your test in Table 1.

D. WHO'S JOLLY NOW?

Your teacher will show you still another bean plant. This plant has been in the dark for 3-5 days.

3. Predict the result of a starch test on this plant.

Cut a small piece from one of the leaves on this bean plant. Repeat the procedure in part B with this piece of leaf. Record the result of your test in Table 1.



E. LET'S HEAR THE WHOLE STORY NOW?

4. What does your iodine test show is missing from the leaves smeared with petroleum jelly or covered with plastic wrap?

5. What did the petroleum jelly or plastic wrap do to the leaves?

6. Look at your answers to "4" and "5." What relationship or conclusion would you draw?

7. What does your iodine test show is missing from the plants grown in the dark?

8. What did the darkness prevent from entering the plant?

9. Look at your answers to "7" and "8." What relationship or conclusion would you draw?

10. You examined part of a leaf under the microscope in part A. What did you find?

11. You tested some leaves that had been sealed with petroleum jelly or plastic wrap. What did you find missing?

12. You tested some leaves from a plant that had been deprived of light. What did you find missing?

Look at your answers to "10," "11," and "12."

13. What gas do you think a plant must have to make starch (food)?

14. How has your experiment proven this?

15. How do you think the gas enters the leaf?

16. How has your experiment proven this?

17. If the plant does not get this gas, what will it be unable to make?

18. If the plant does not get any light, what will it be unable to make?

Your answers to "17" and "18" will be a guide to the Concept Summary.

CONCEPT SUMMARY. (What general concept have you learned in this investigation?)

Investigation 3

The Importance of Being Green

Most of us live in a world that is gray—a world of sidewalks, pavements, and buildings. The real world to most people is not the green world of flower blossoms, grain fields, and acres of trees.

Henry Monroe from dpi

Bruce Roberts from Rapho Guillumette

By the year 2,000, some 85 percent of the people may live in urban (city) areas. By the end of this century, most human beings may be born, live, reproduce, and die within the limits of an urban area.

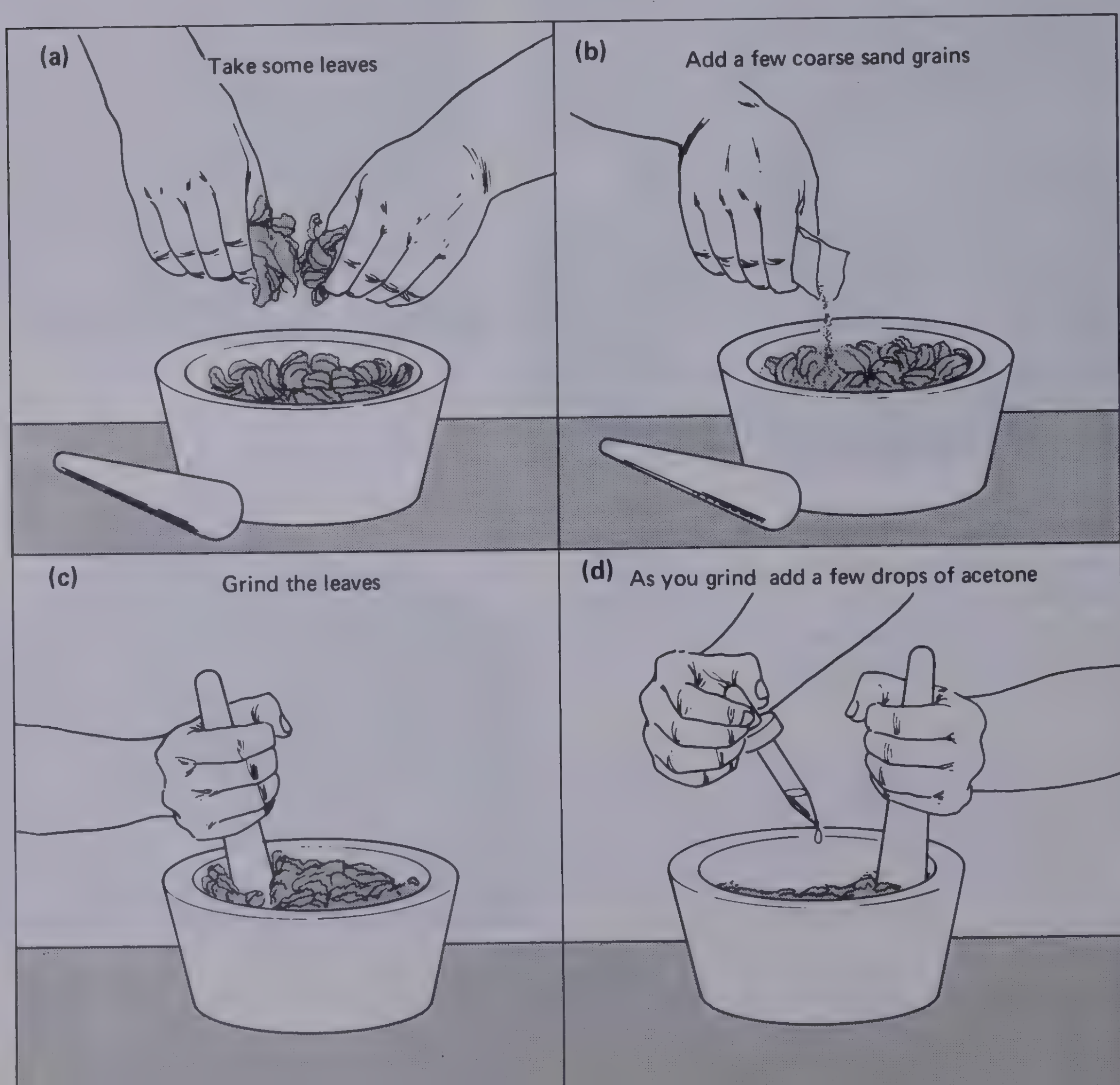
Clark Equipment Co

Each time we plow a field for a highway, bulldoze a woods into a shopping center, or turn farmland into a housing development, we are turning more of the great green world into the dull gray world.

Can man learn to live in harmony with his world of green? If he destroys much more of his green world, what will happen? Why is green so important to life?

A. GREEN POWER

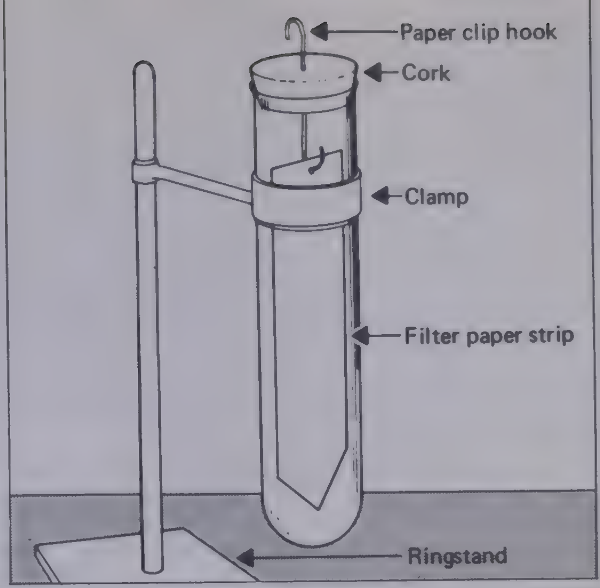
Take some leaves and add a few coarse sand grains. Grind the leaves in a mortar with a pestle. Add a few drops of acetone as you grind the leaves. You will note that the acetone turns green. Try to get as concentrated a drop or two of green acetone as possible. Therefore, add only enough acetone to get a green liquid.

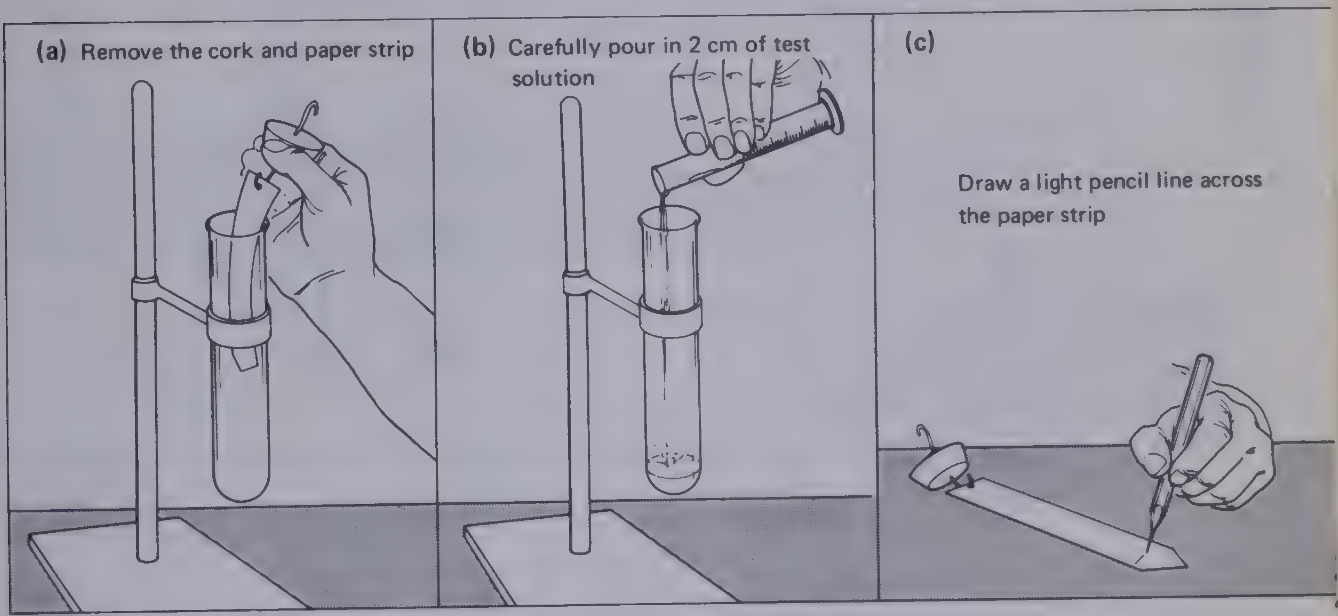


You will be given a strip of filter paper, a large test tube, a cork, a paper-clip hook, and a stand. Assemble the pieces as illustrated in the apparatus diagram.

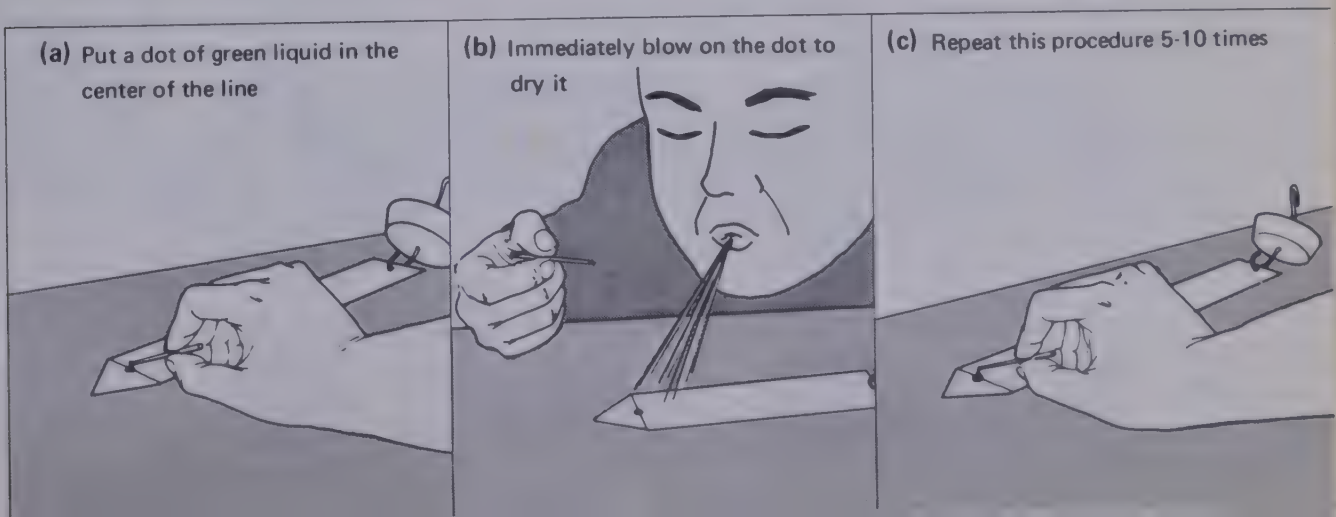
Remove the cork and paper strip from the test tube. Carefully pour in 2 cm of the test solution provided by your teacher.

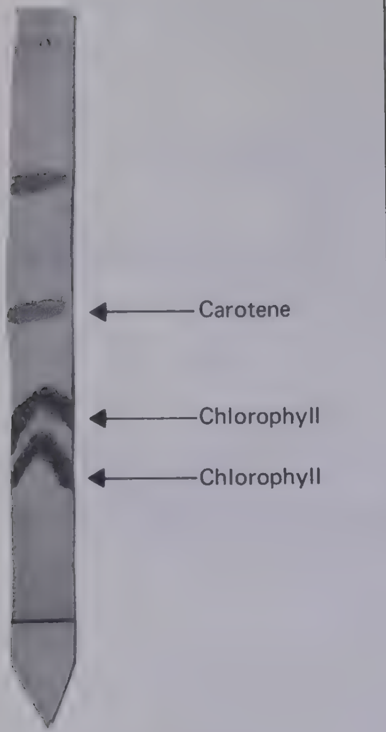
Draw a light pencil line across the paper strip. Make this line 1 cm higher than the level of the test solution in the test tube.





Do the next part slowly and carefully. Using a thin glass rod or toothpick, put a dot of the green liquid in the center of the line. Immediately blow on the dot to dry it. Repeat this procedure 5-10 times. Try to get as concentrated and as small a dot as possible. Hang the filter paper strip in the test tube as shown in the apparatus diagram above. Do not disturb for 20-30 minutes.

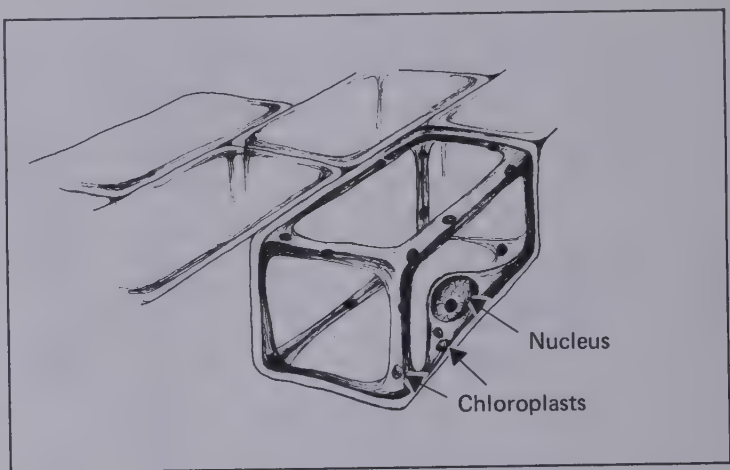




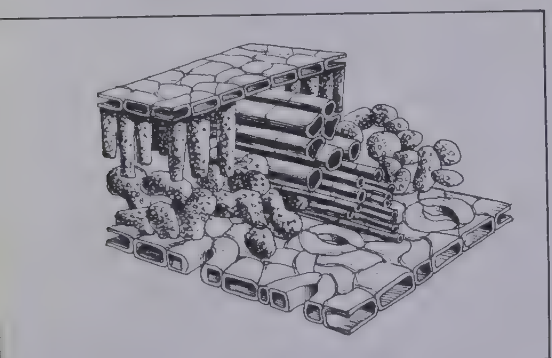
When you remove the strip, tape it in space *a* of your data sheet. Compare your strip with the photograph. Note the color bands on your strip. There are some yellow bands and some green ones. The yellow bands contain the substance that gives a carrot its color. You may know about the green bands. They contain a substance called *chlorophyll.*

If a thin section of leaf were cut with scissors, a microscopic section of the leaf would look like the drawing.

If one of the cells is examined more closely, you would find small objects called *chloroplasts.* They contain the green substance chlorophyll. Of what importance is chlorophyll?



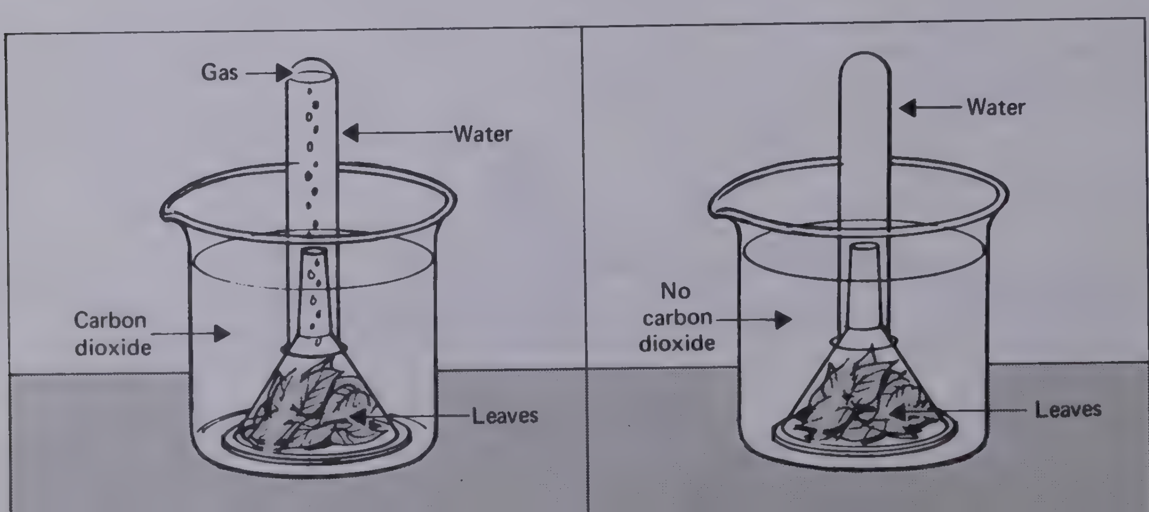
A Plant Cell



Cross-section of a Leaf

B. SHREDDED LEAVES, ANYONE?

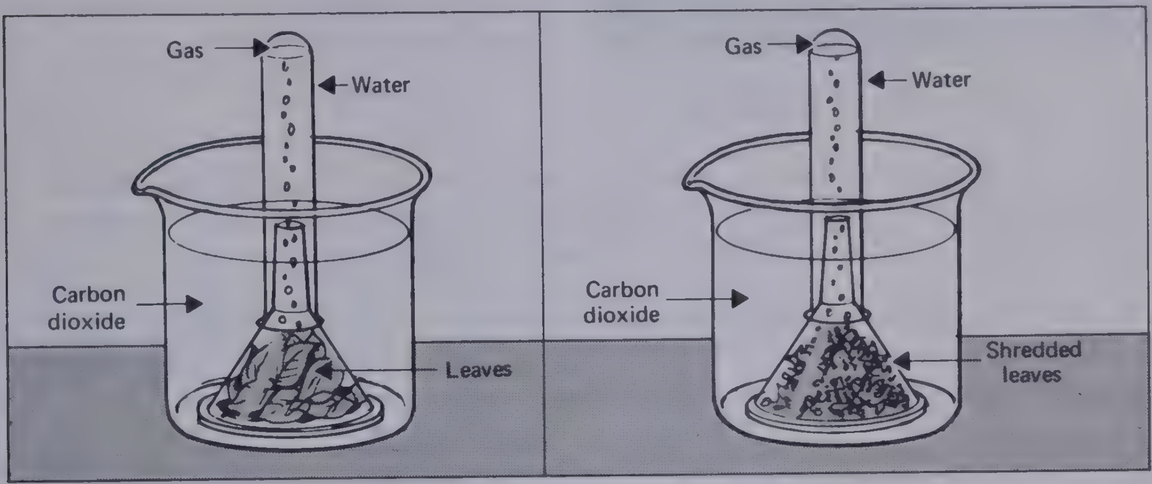
Around 1770, a scientist put some leaves in two beakers of water. One container of water had carbon dioxide in it. The other did not have carbon dioxide in the water. A funnel and test tube were placed over each group of leaves. See the setup pictured.



1. What do you observe happening in one group of leaves?

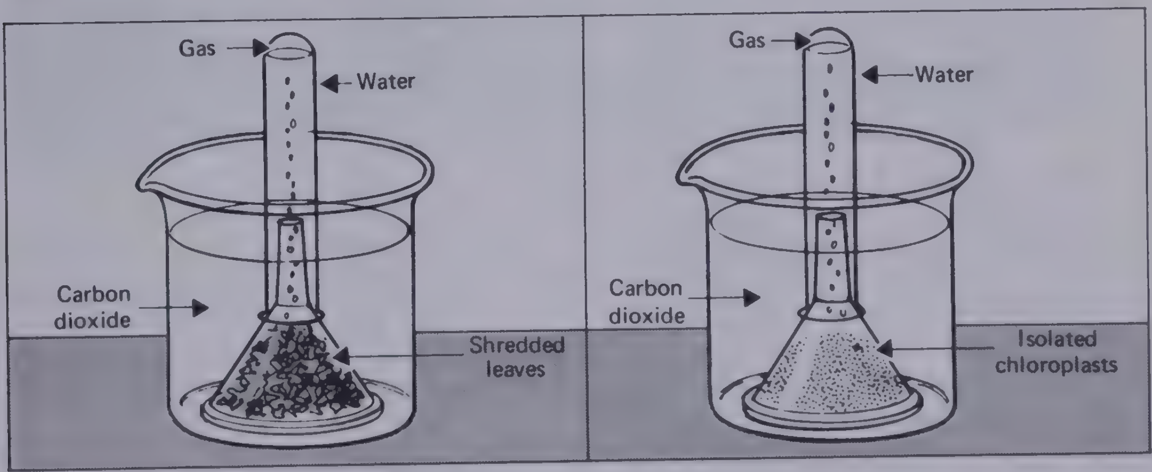
2. What gas seems to be necessary for what is taking place?

The same scientist repeated his experiment with a variation. He put whole leaves in one container of water and shredded leaves in the other container. The water in each container had carbon dioxide in it.



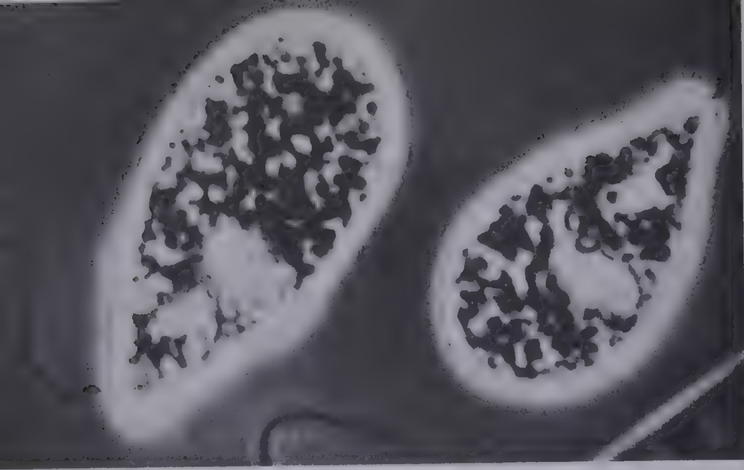
3. According to the results pictured, do you think whole leaves are necessary for a bubbling activity to take place? Explain.

In 1954, another piece of a puzzle was discovered by a group of scientists. Shredded leaves were placed in one container of water with carbon dioxide and a bubbling activity was observed. However, in another container, chloroplasts that had been removed from leaf cells were put into water with carbon dioxide. See the drawing for the result.



4. What do you observe happening in the container with the chloroplasts?

5. According to the results shown so far, all a plant needs to produce bubbles is __?__



Walter Dawn from National Audubon Society

Let's review the three experiments shown in the drawings above.

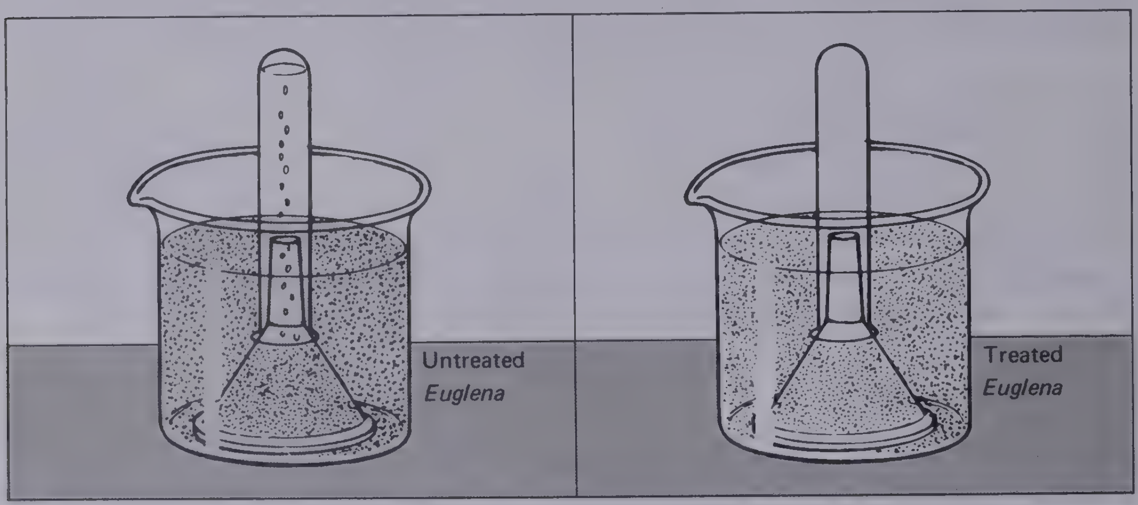
6. According to what you have learned, what has to be present in the water before the bubbles will form?

7. What part of the plant must be present before the bubbles will form?

C. THE JOLLY GREEN EUGLENA

Now, let's look at one more experiment. Remember the green organism called *Euglena.* It swims around in a drop of water like the paramecium and ameba. Is it an animal? It moves. But it's green. Is it a plant? Is there such a thing as a green animal?

Study the experiment pictures. You will see that one container has untreated *Euglena* in it. That is, nothing was done to these *Euglena*. The *Euglena* in the other container, however, have been treated. The green substance has been bleached out of the *Euglena.*



8. Which group of *Euglena* showed a bubbling activity?

9. Which group of *Euglena* died?

10. Why do you think these *Euglena* died?

11. What was the only factor different between the two groups of *Euglena?*

12. What is the chemical name of this important factor?

13. In summary, what substance is necessary for plant life?

CONCEPT SUMMARY. (What general concept have you learned in this investigation?)

Investigation 4

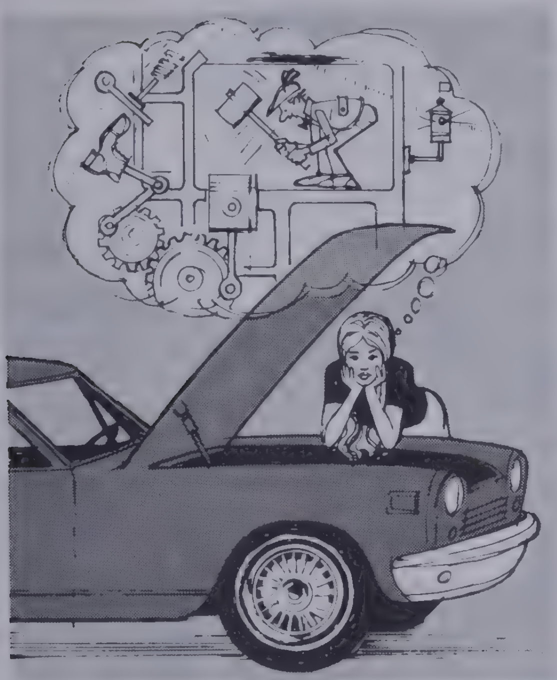
Your Life Depends on Plants

By now you may be aware that you have been building another model. A model, you will remember, is a mental picture of a real thing. You've already built two models in *Genetics* and *Homeostasis:*

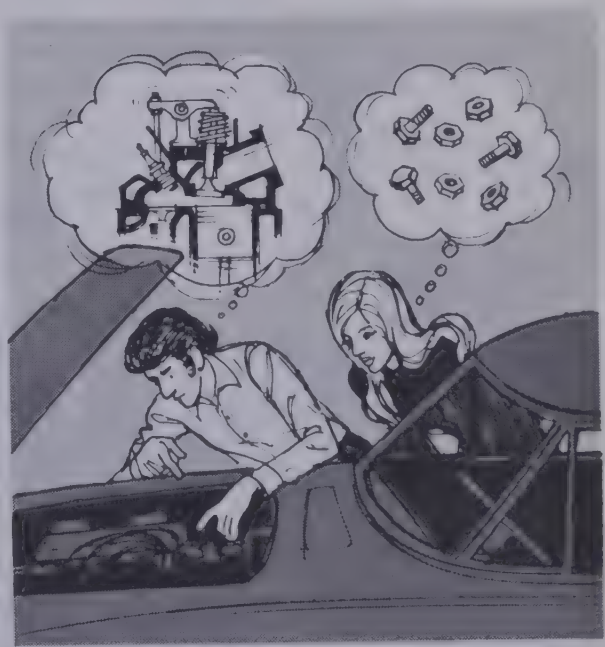
a. a model to explain how the pattern of inheritance works, and

b. a model to explain how the body processes stay in balance.

You build mental models every day. For instance: If you hear strange knocking sounds coming from your car as you drive, you may form a mental model of your trouble, as in the first picture.



Or, your mental model may be that shown in the second picture.

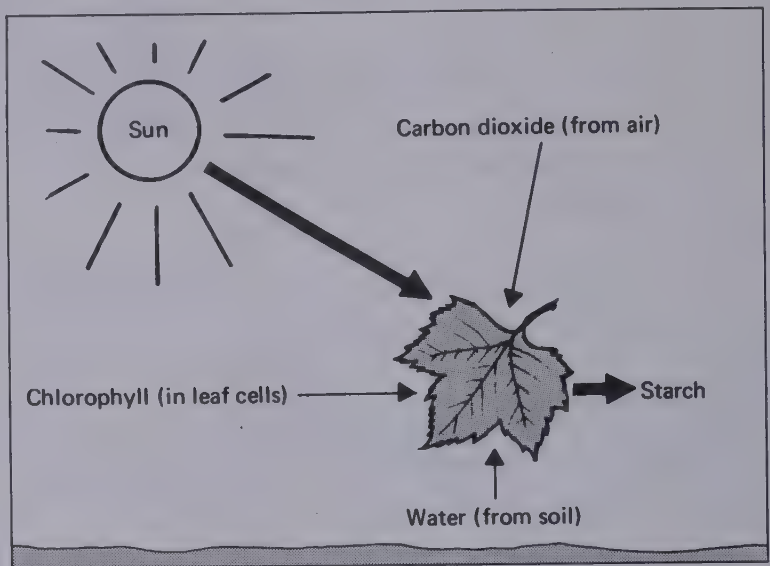


The model you have pictured in your mind depends on your background and experience. If you know nothing about cars, you may think like the girl shown. On the other hand, if you know something about cars, you may think like the guy.

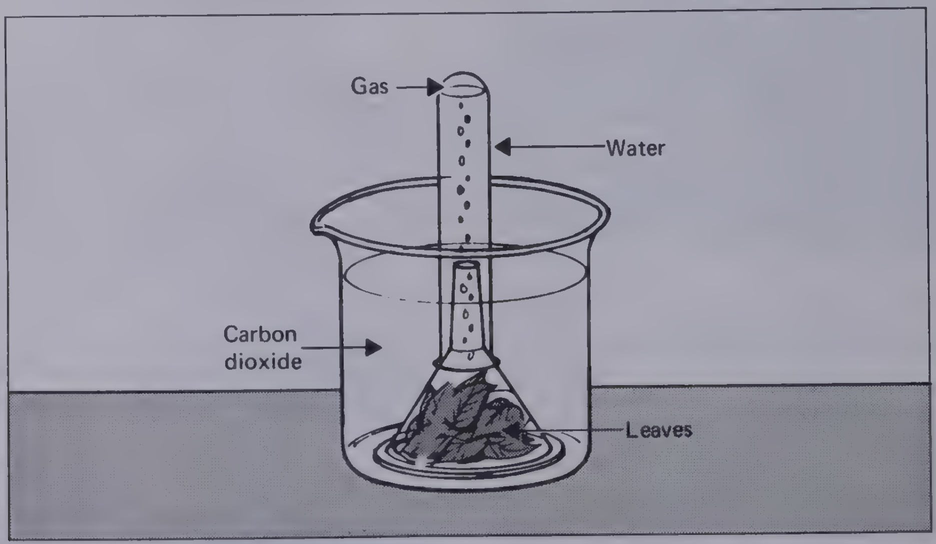
How well you make a model depends on how well you know your subject. As you learn more about a subject, you will change and improve your model.

A. THIS MODEL COMES IN GREEN

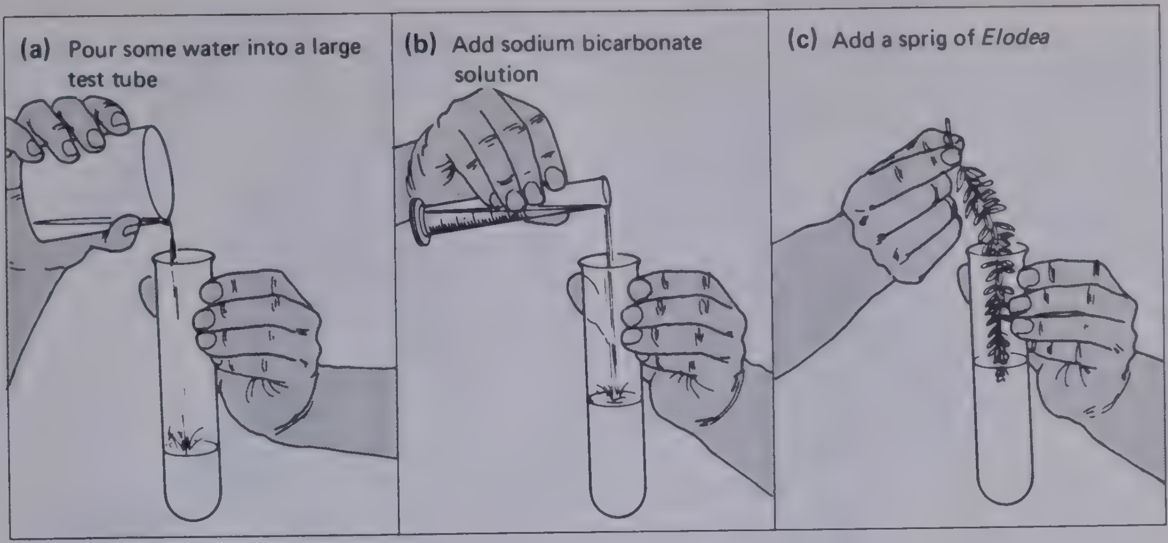
This is an ordinary leaf. If someone asked you to explain what was going on inside the leaf, you might have had trouble thinking of a model a week ago. But you know something about leaves now. Does your model look like this?



You have learned that a leaf needs carbon dioxide, light, and chlorophyll. In addition, a leaf needs water and the minerals dissolved in the water. Thus, you have seen that if a leaf has these four things, it can make starch and sugar.



But you've also noticed something else. Leaves in water give off bubbles. What kind of gas are these bubbles? Let's set up an experiment according to the model, to investigate the nature of these bubbles.

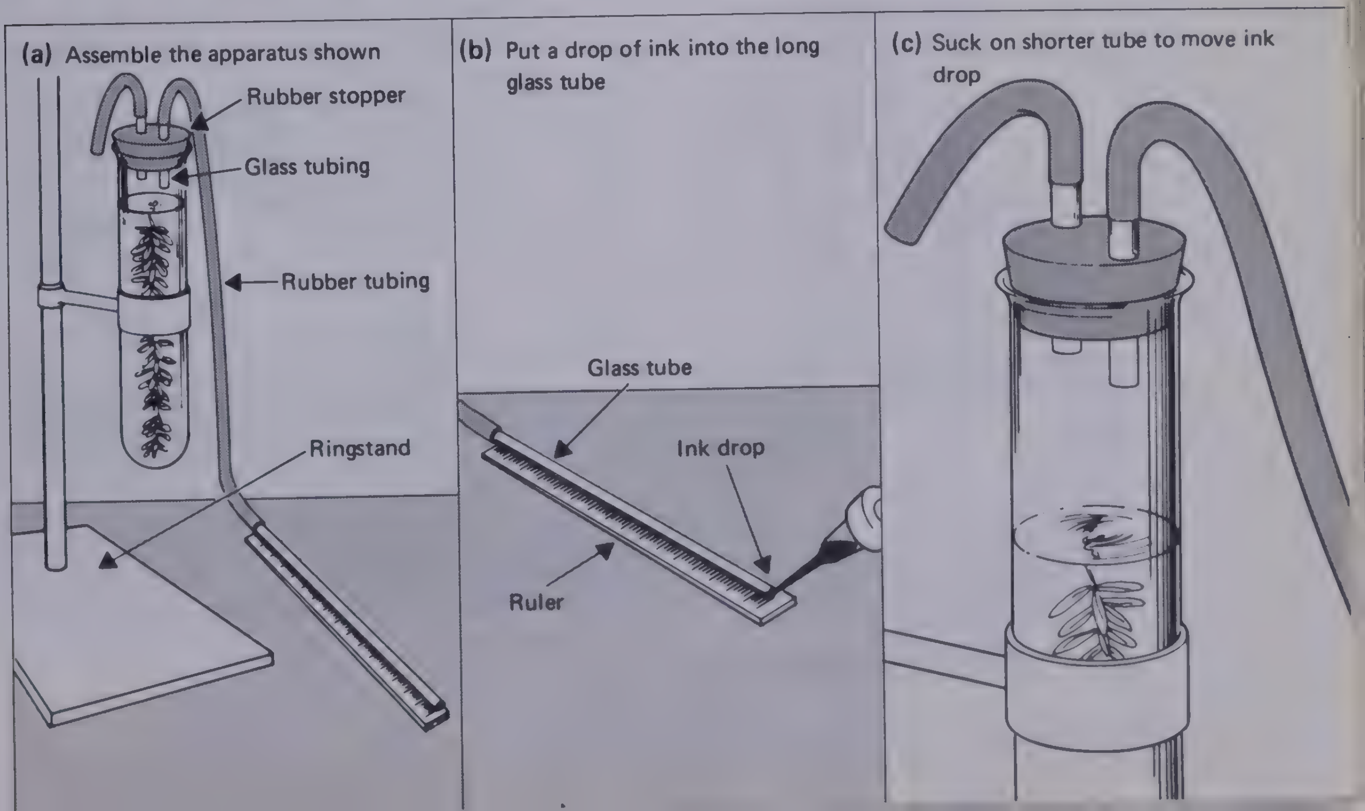


Place some *water* and baking soda into a large test tube. The baking soda is the source of *carbon dioxide.*

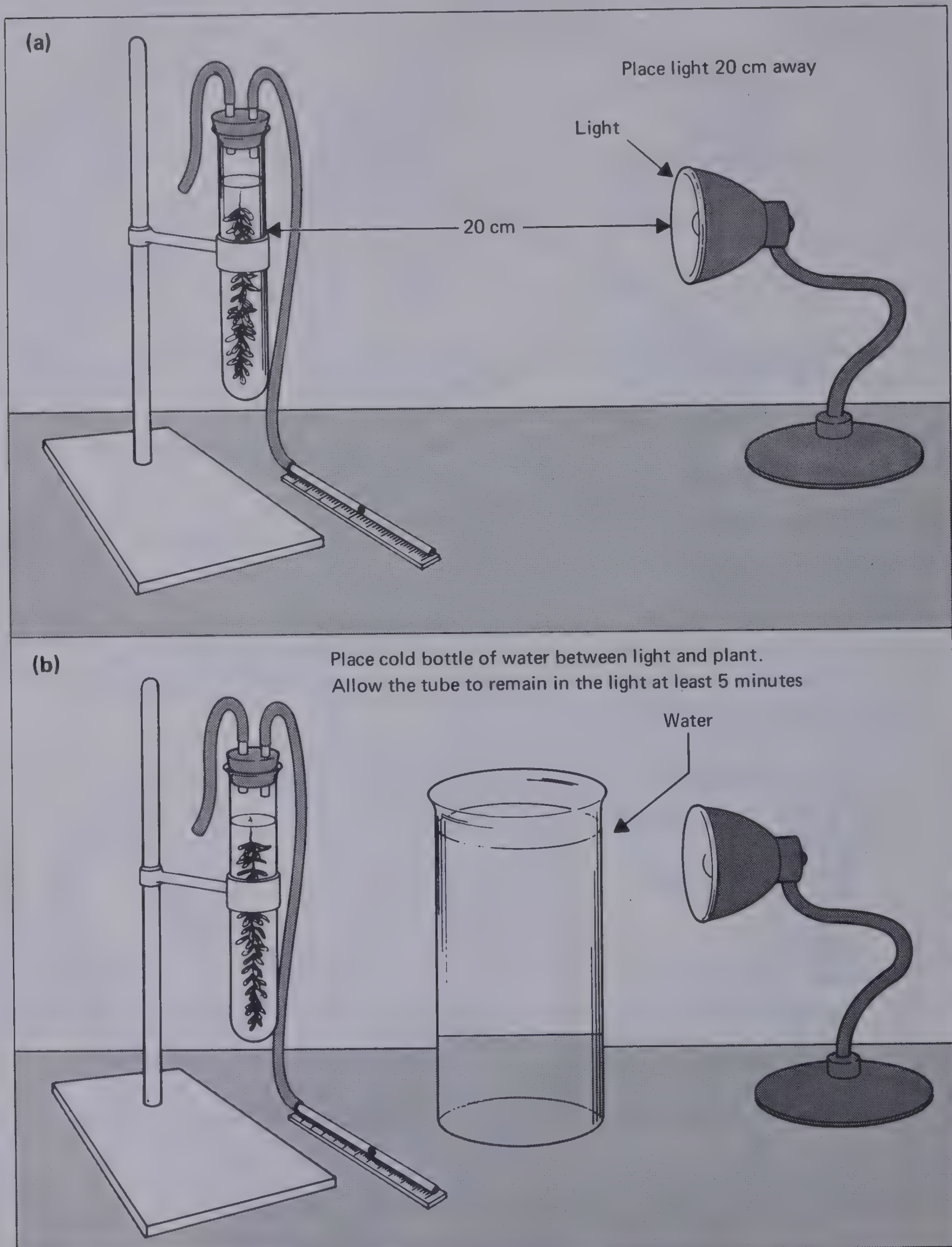
Put a few sprigs of *Elodea* in the test tube. Put them in upside down. The green color you see in the leaves of the *Elodea* is *chlorophyll.*

If you put the test tube in the *light,* you will have the fourth and last thing your model says is needed by a leaf.

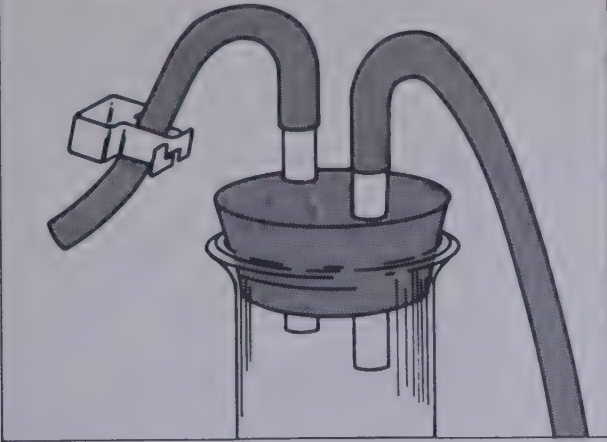
You will now need some way to measure the bubbles. Assemble the apparatus as shown in the diagram. Using a fine eyedropper, put a drop of ink into the long glass tube. Move the ink drop to the middle of the tube by sucking on the smaller length of rubber tubing. Place the ruler along the side of the glass tube.



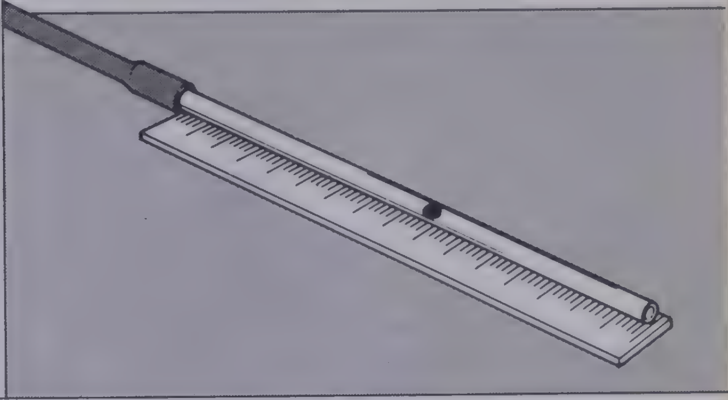
Place a light about 20 cm away. Allow the test tube to remain in the light for at least five minutes. If a fluorescent light is not used, place a cold bottle of water between the light and the plant to absorb the heat.



(a) Clamp the shorter tube shut



(b) Immediately note and record the position of the ink drop. Run the experiment 1-3 minutes



1. If you do not use a bottle of cold water, how many factors will you have affecting the experiment? Name them.

2. Every experiment should be limited to how many factors?

When you are ready to begin, clamp the shorter tube shut. Immediately note the number on the ruler at which the ink drop begins. Record this number in Table 1.

Allow the experiment to run for 1-3 minutes. At the end of this time period, note the position of the ink drop. In Table 1, record the time and the distance the drop moved.

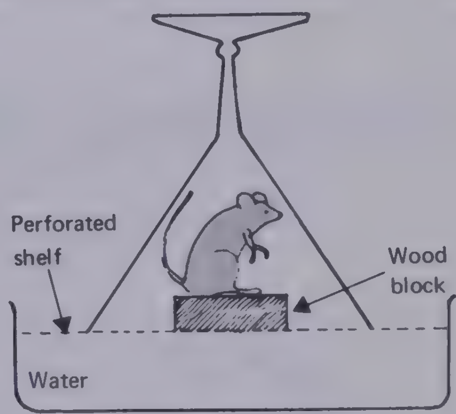
If you choose, there is room in the data table for two more runs. If the ink drop has moved too far from the middle, return it to the middle before starting a new run.

3. Did the ink drop move? In what direction?

4. What does this activity indicate the *Elodea* is doing?

5. This experiment lacks a control. How would you set up a control?

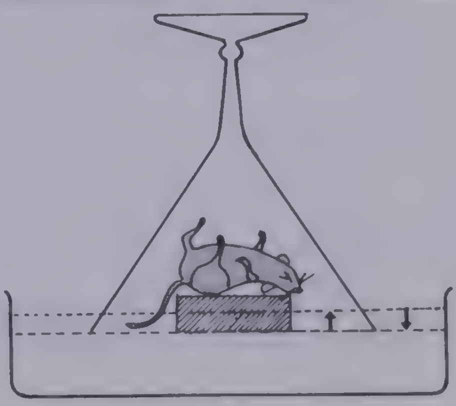
6. What gas do you predict the *Elodea* is producing?

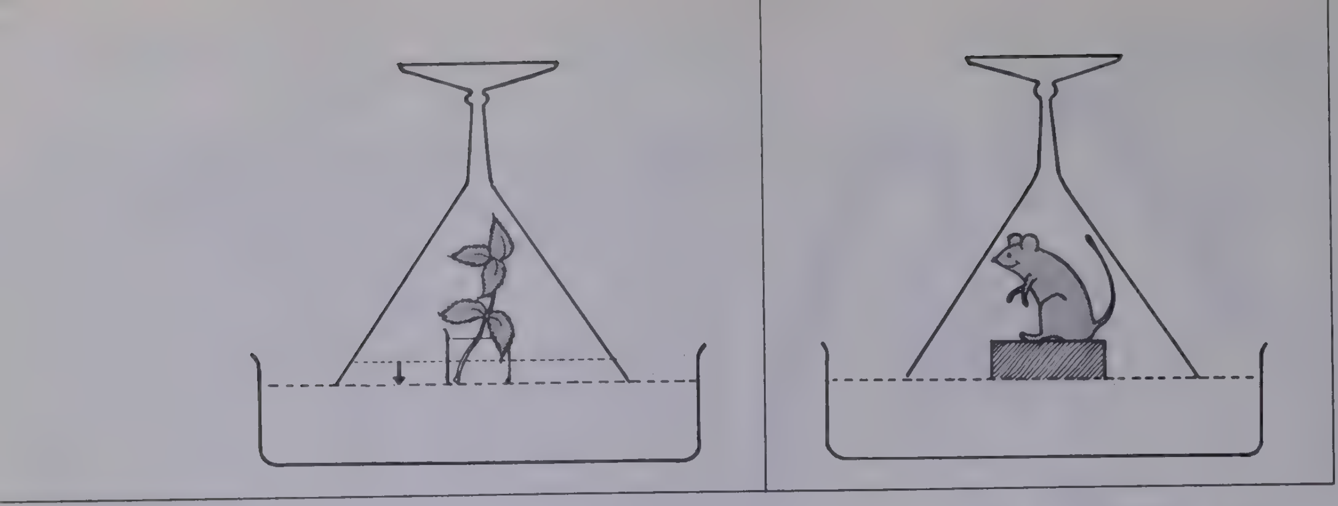


B. BE GRATEFUL FOR "BUBBLES"

By reading the following experiments, you should be able to determine if you predicted correctly.

If a live mouse is placed in a closed container holding water, it will live for a short time. After a while, the water will rise up to fill 20% of the container. The mouse dies.





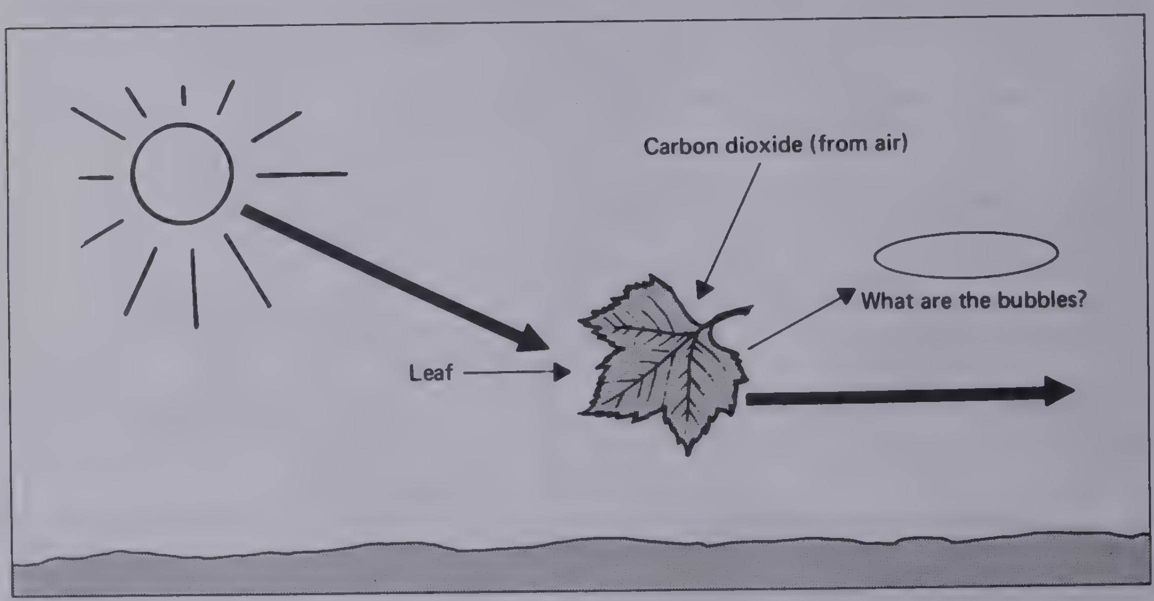
If a plant is placed inside the container, the water will slowly drop to its original level. If a live mouse is now placed in the closed container, it will live for a while again.

This series of experiments was first performed by Joseph Priestly in 1771. His experiments will help explain the final product of your model.

7. What do you think was a possible cause of the mouse's death?

8. Why do you think the water level rose?

9. Why would a plant cause the water level to drop back down?



10. What gas would you say a plant gives off?

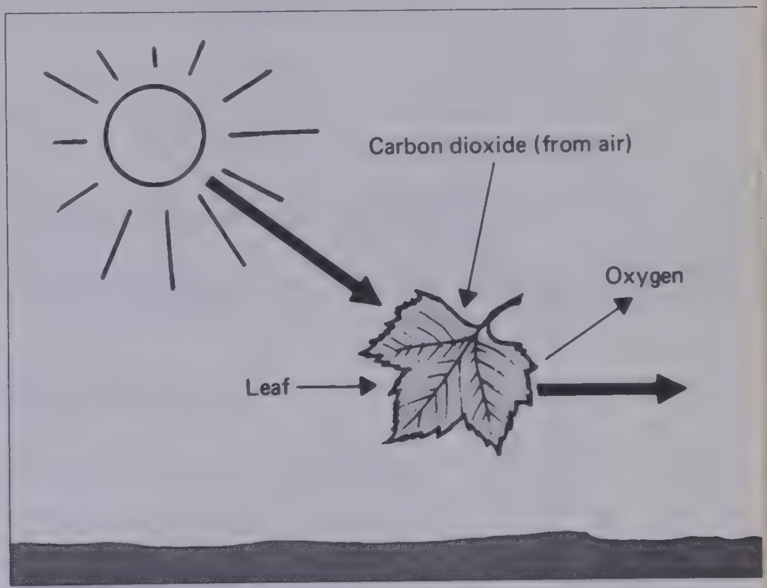
11. What do you think all plants produce?

CONCEPT SUMMARY.

Investigation 5

Bubble, Bubble, Toil–No Trouble

You have been experimenting with plants in the last four investigations. From these experiments, you have been developing a model which tells you how plants interact with their environment. Your model tells you that many things in the environment, such as light, carbon dioxide, water, and chlorophyll, are needed by plants. Your model may look like the diagram shown.

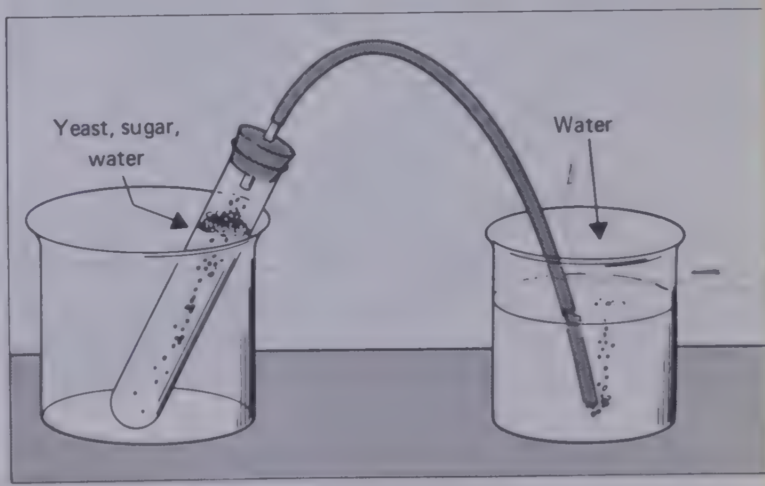


Your model shows the process by which plants make starch and sugar. This process is called *photosynthesis.* Photo means "light" and synthesis means "to make." Therefore, photosynthesis refers to a plant's ability to make starch and sugar in the presence of light. What does a plant do with the starch and sugar that it makes?

Harvesting Sugar Cane

A. CAN YOU PREDICT?

You will be shown two test tubes. Each has sugar, water, and yeast in it. Each container is closed and a tubing leads from it into some water. What do you think is the cause of the differences between the two test tubes?



1. Remember, a scientist is a good observer. What do you see?

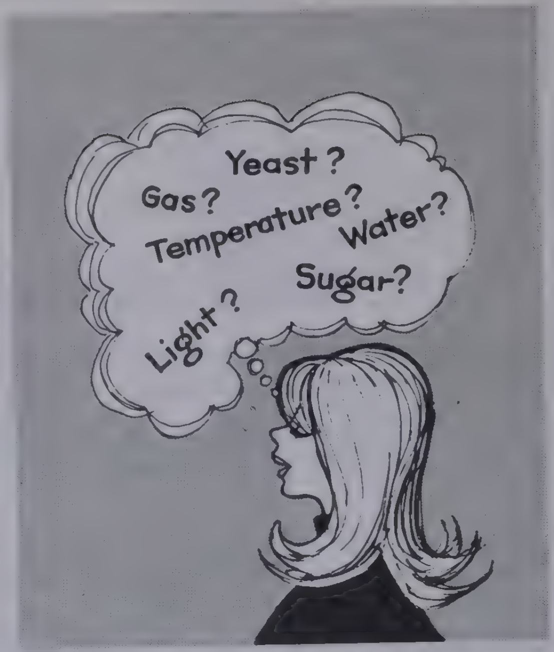
2. What do you predict is the reason for the differences? List your predictions. (To help you get started, one prediction is given.)

Your list of predictions represents possible solutions to the problem.

3. Would you test all your predictions at once? Explain.

Scientists often make predictions about an experiment. This helps them to find the answer.

4. How can you find which of your predictions is the cause of the differences?



B. LET'S TEST YOUR PREDICTION

Before we begin, let's make sure that we know what we are looking for. Remember, your predictions will guide the experiment.

5. Which one of your predictions will you test in this experiment?

6. How will you set up your control?

The photograph is an illustration of the setup you were looking at earlier.

7. Explain how you will prepare and run your experiment.

Obtain the necessary materials from your teacher and assemble your experiment.

C. LOOKING FOR SOMETHING?

What will you be looking for in your experiment?

8. What data will you collect?

Organize your data by constructing a table in your data sheet (Table 1). Draw a graph of your results in Graph 1.

9. What conclusion(s) can you draw from your data?

10. What are some possible sources of error in this experiment?

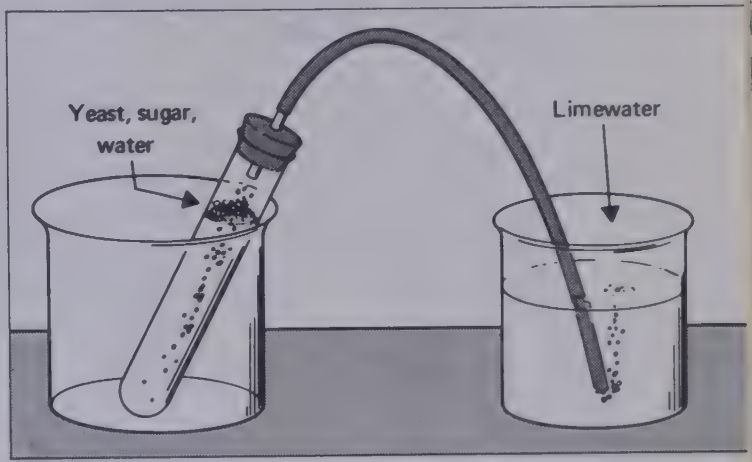
D. IT NEVER ENDS

Just when you think you've drawn a conclusion, you find out there is more to learn. Science can certainly keep you thinking. For instance, some of you may be wondering about the bubbles. You may be asking:

a. What kind of gas is making the bubbles?

b. Where does the gas come from?

To help you answer the first question, you will be given some limewater. Allow some of the bubbles from your experiment to bubble into the limewater.

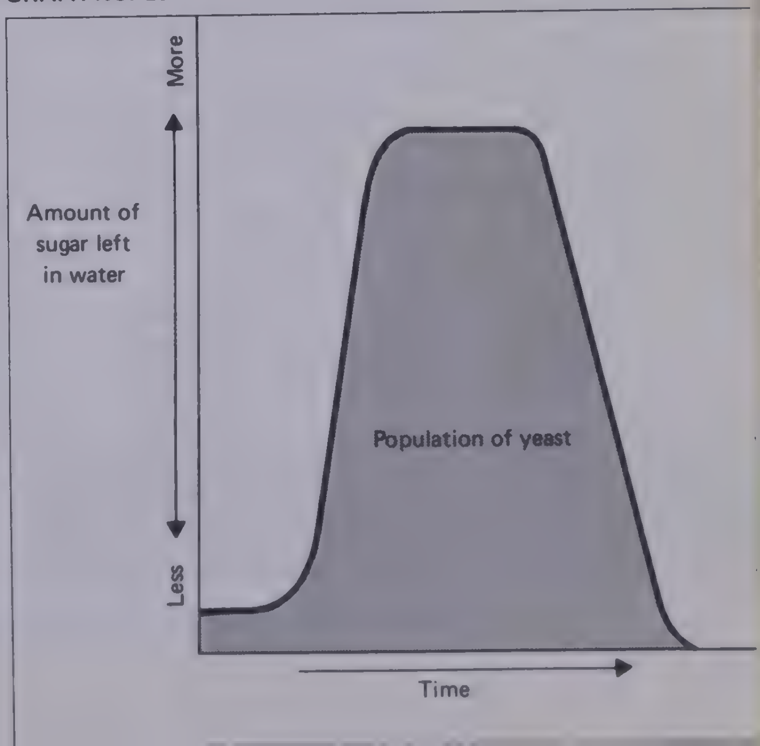


11. What happens to the color or condition of the limewater?

12. What gas is bubbling into the limewater? (If you have forgotten the purpose of the limewater, check your results in Idea 1, Investigation 4.)

Where is the gas coming from? It can't be from the water in the tube, because water is made of hydrogen and oxygen (H_2O). That leaves either the yeast or the sugar. Could it be possible that the gas comes from the yeast?

GRAPH NO. 2



Study Graph 2.

13. According to the data in Graph 2, why do the yeast die?

14. Why is the sugar important?

15. What is the yeast able to obtain from the sugar?

16. In order to obtain energy, what must the yeast do to the sugar?

17. Where do you think the gas is coming from?

In conclusion:

18. What must happen to food after it is eaten by living things?

19. In the process, what is obtained from the food?

20. What is released as a waste gas?

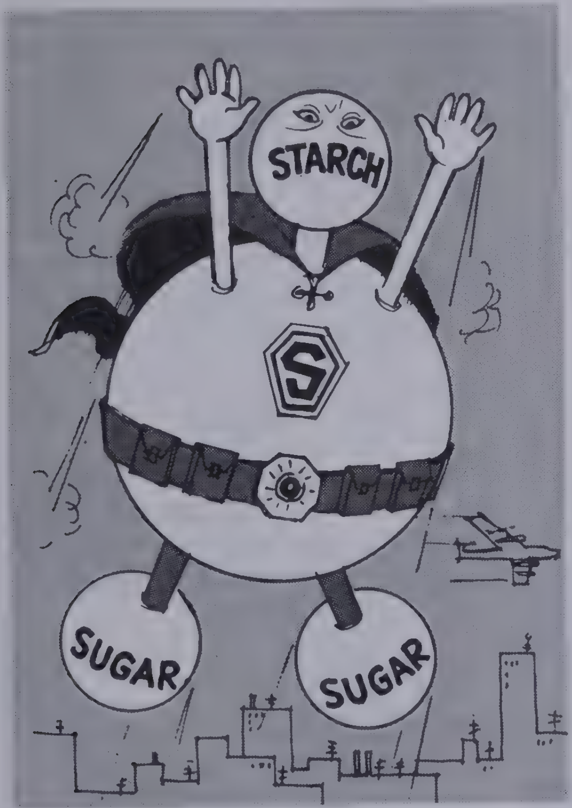
Combine your answers from questions 18-20 for your concept summary.

CONCEPT SUMMARY.

Investigation 6

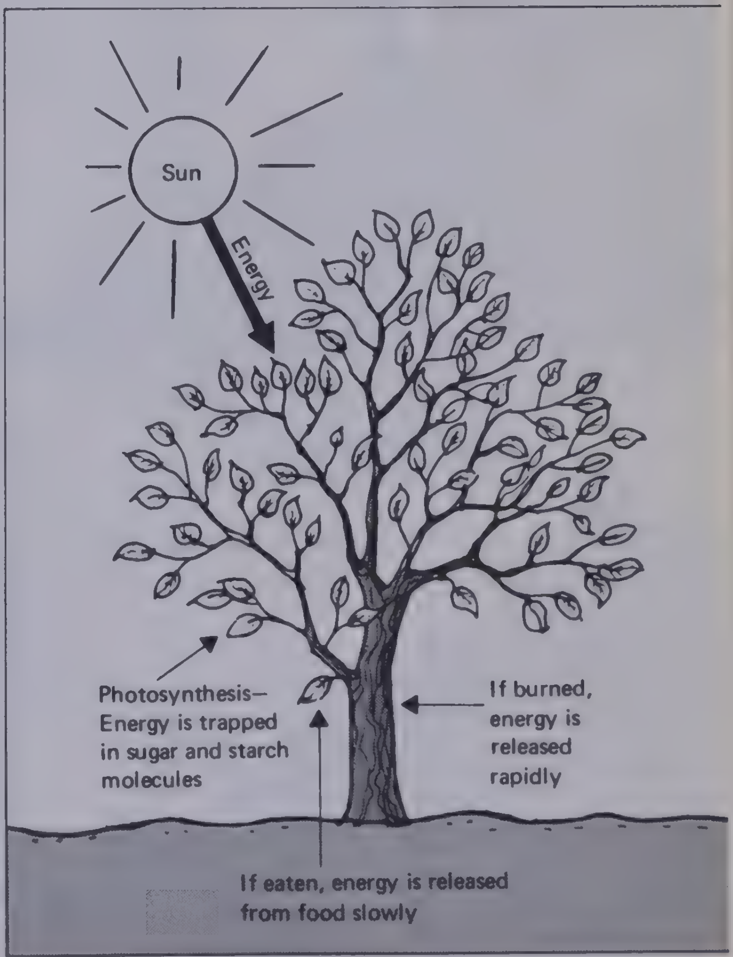
Look, There in the Food!

The food that you eat must supply you with the energy you need for living. Where does this energy come from?



Is it a carbohydrate? Is it a protein? No! It's Superfat! A strange visitor from another meal—who, disguised as a starch molecule, fights a never-ending battle against hunger and famine.

Green plants on the earth obtain energy from sunlight. Through a process known as photosynthesis, green plants convert some of the sun's energy and manufacture sugar and starch. These plant foods are called carbohydrates. They are stored by the plant and used as needed.



Animals cannot use the sun's energy to manufacture foods. In order to live, animals must either eat green plants or other animals which live on green plants. This process is called a *food chain*. A food chain shows that living things are dependent upon each other.

A. TIME FOR ANOTHER MODEL

It's time to build another model or mental picture. You have already constructed a simple model that helps explain how plants capture energy, convert the energy into food, and store it for later use. This model explained photosynthesis, a process of using the sun's energy.

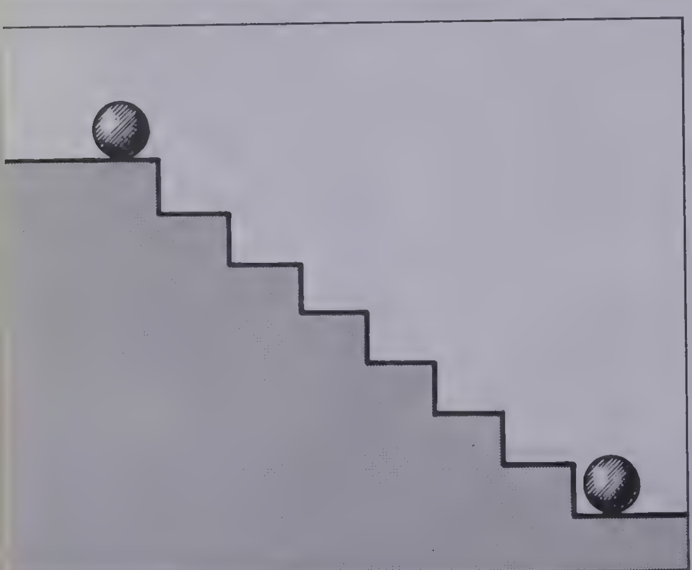
The process of photosynthesis is very similar to a boy carrying a ball to the top of a flight of stairs. A ball that sits at the bottom of the stairs cannot do very much work. It has no energy.

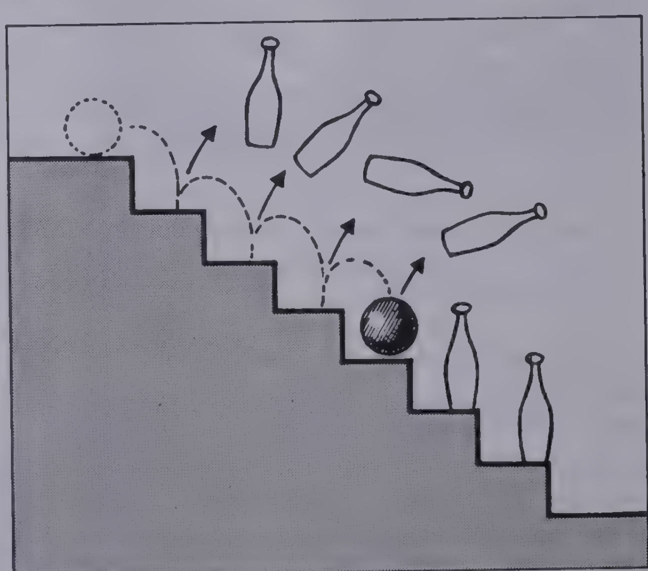
If a boy carries a ball to the top of the stairs, he has put energy into it. The ball can fall down the stairs and do work. For instance, it can knock pins over.

Hold some peas in your hand. They are round like a ball. But are they like the ball at the bottom of the stairs or at the top of the stairs? In other words, do the peas contain any energy? Let's see.

B. IT'S A REAL GASSER

Fill a test tube half full of pea seeds that have been soaked overnight. Place a wad of cotton over the peas and add 15 pellets of potassium hydroxide. In Investigation 3

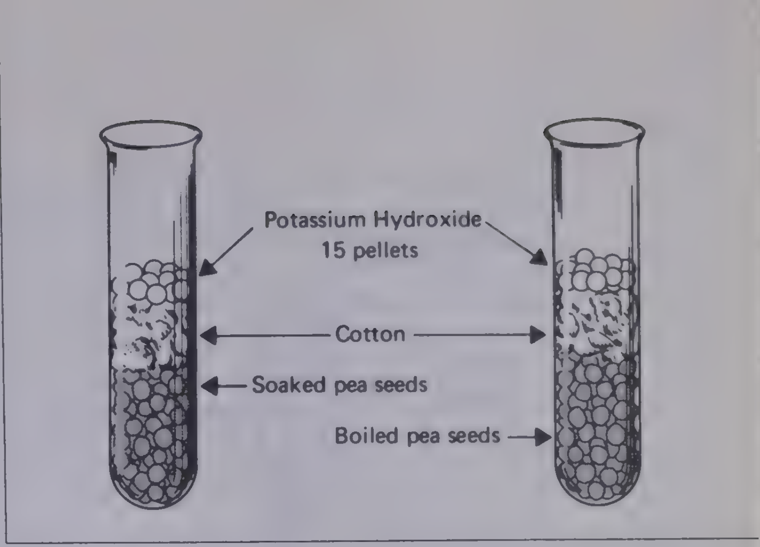




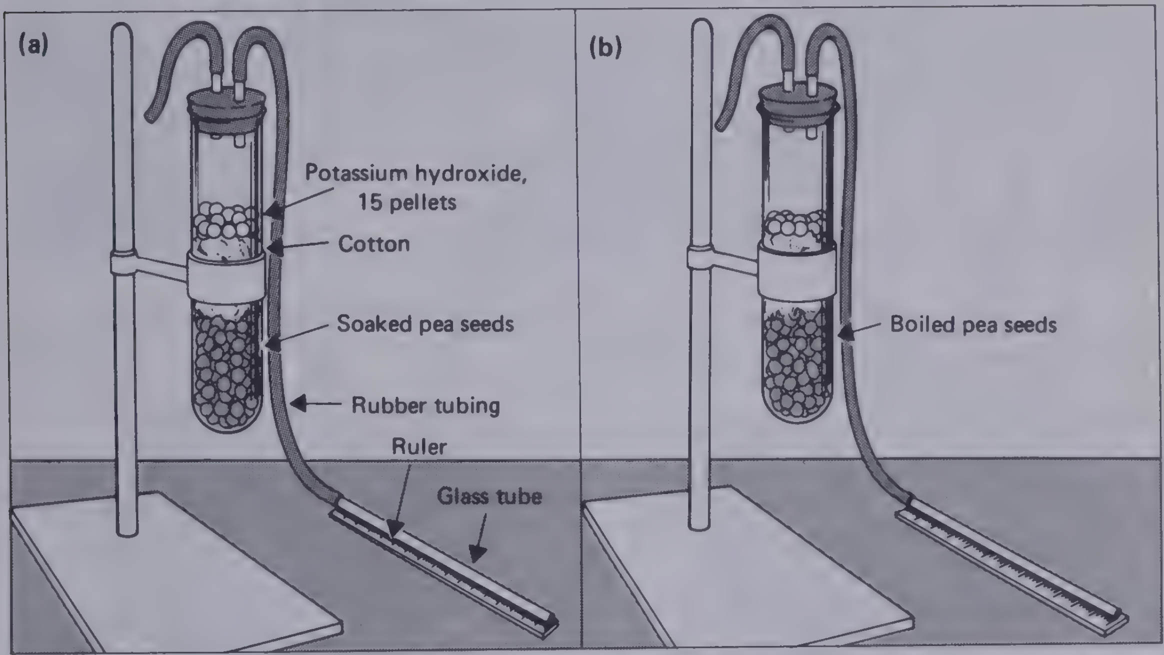
your teacher may have used potassium hydroxide to absorb carbon dioxide from a plant sealed in an airtight plastic bag.

CAUTION: DO NOT TOUCH POTASSIUM HYDROXIDE PELLETS. USE YOUR FORCEPS.

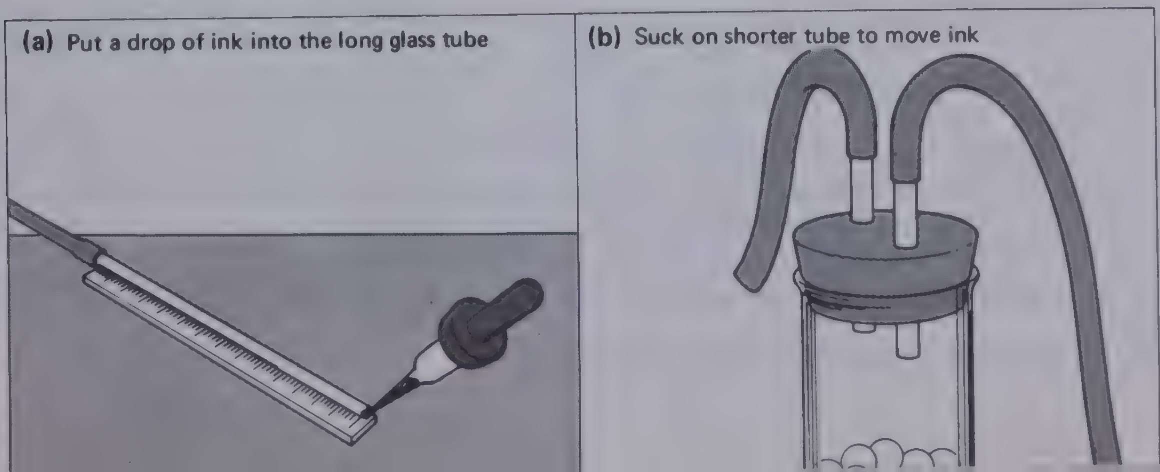
Fill another test tube half full of pea seeds that have been boiled for at least five minutes. Place a wad of cotton over these peas and add 15 pellets of potassium hydroxide.



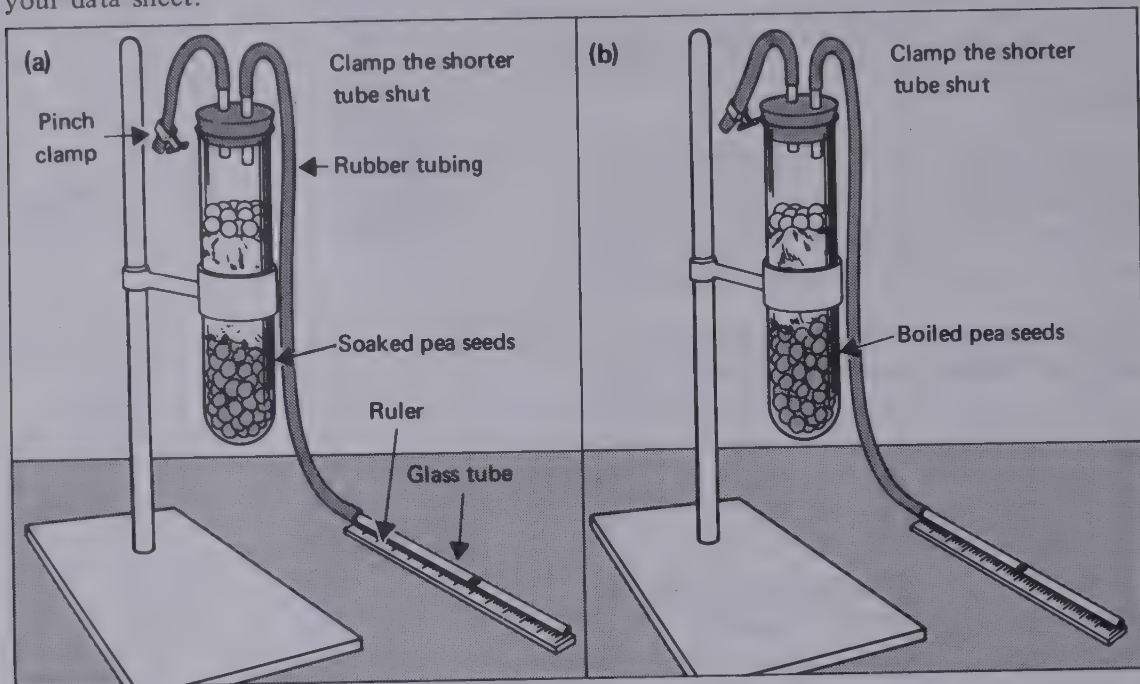
Use the same apparatus as in Investigation 5. Place a stopper on each test tube and tape the long glass tube to the ruler on the table.



Using an eyedropper, place a drop of ink at the tip of each of the long tubes. Move the drop to the center of the tube by gently sucking on the shorter rubber tube. Do not disturb the entire setup for 2-3 minutes.



When you are ready to begin, clamp both of the shorter tubes shut. Immediately note the starting points of the two ink drops on the rulers. Record these two numbers in Table 1 of your data sheet.



After 3-5 minutes, note the final locations of the two ink drops and calculate the distance the drops moved. Record these numbers in Table 1.

1. What do you think boiling and soaking did to the pea seeds?

2. If all of the carbon dioxide is absorbed by the potassium hydroxide, what indicates that another gas is being absorbed by the seeds?

3. Did both drops move toward or away from the tube of seeds?

4. What do you think the seeds are doing to cause the movement you saw?

5. What gas do you think some of the seeds are absorbing?

6. How do you know which test tube contains the living seeds?

7. A clue that an organism is living is that it is taking in what gas from the air?

8. A seed needs energy to remain alive. It needs much more to grow, to push its roots through the soil, and to push its stem up out of the soil. It needs this energy before it can ever make food by photosynthesis. Where do you think this energy comes from?

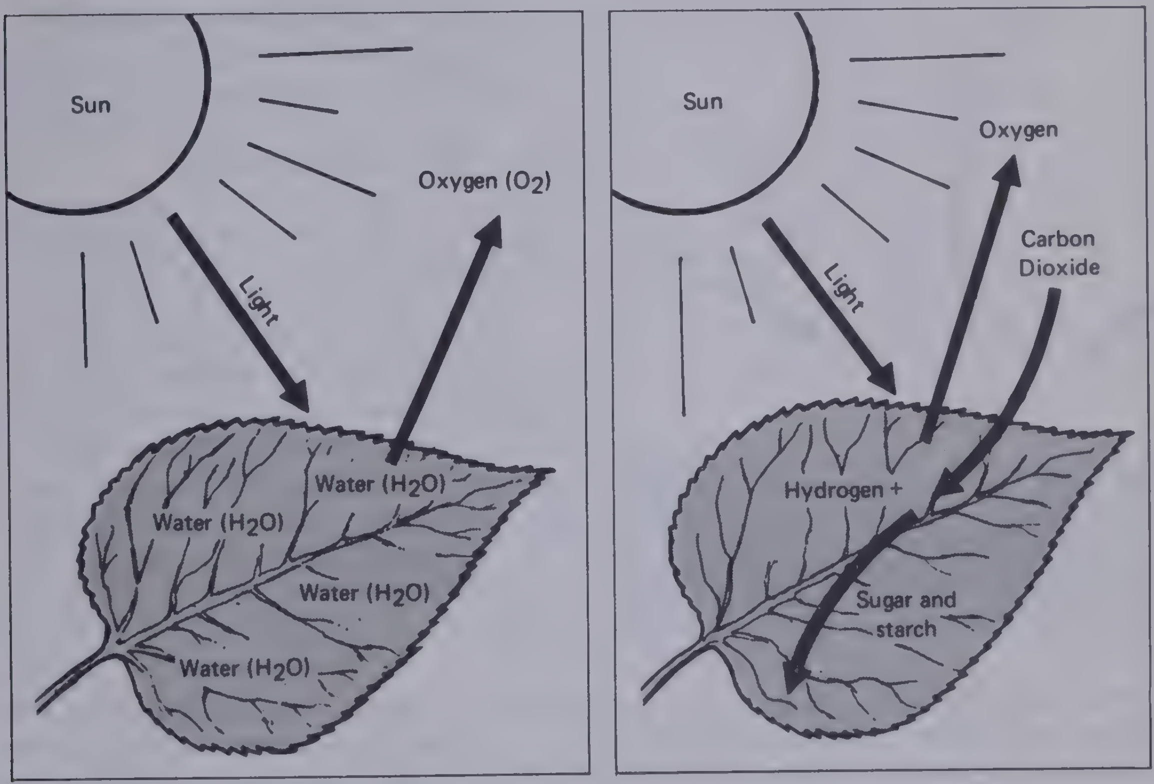
9. What gas do you predict must be present for this energy to be released?

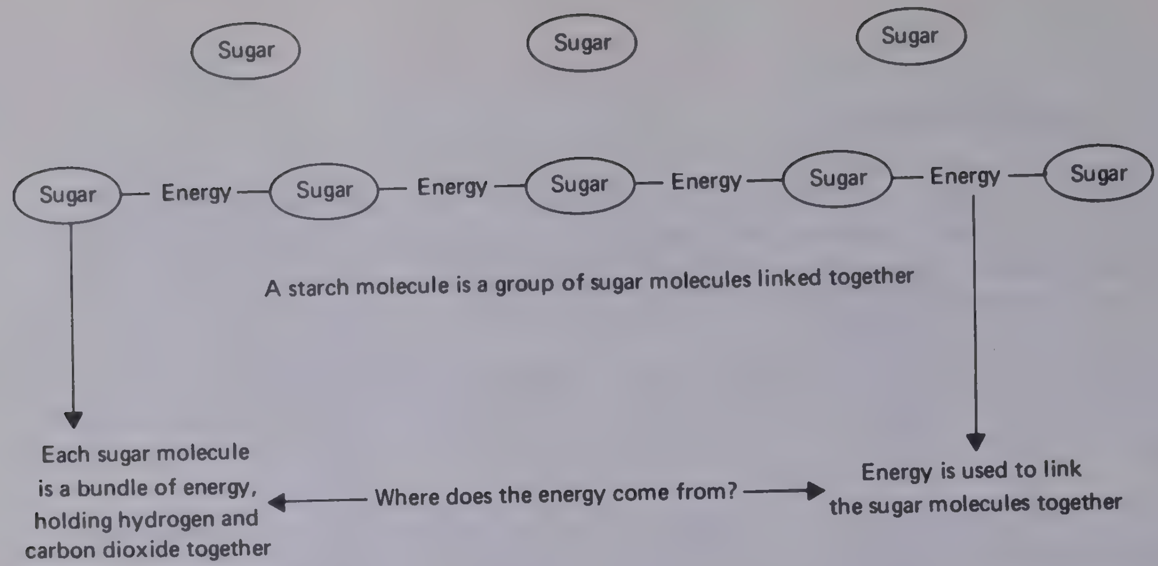
C. LET'S FINISH THE MODEL

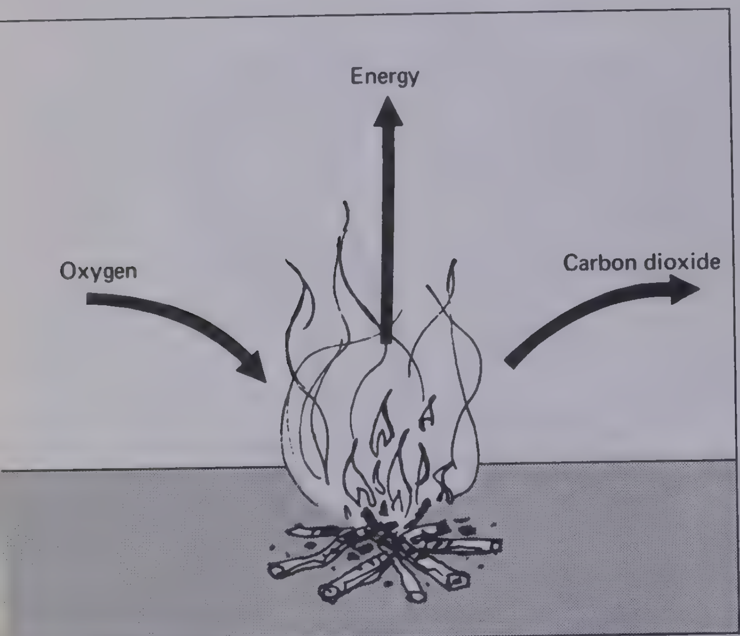
Let's see if you can put a model together to explain how energy is stored and used at a later time. The model comes in two parts. The first part is the "synthesis." The word "synthesis" means to make, to build, or to put together. The word "photo" means light. Thus, photosynthesis means to put together with light.

When sunlight shines on a leaf, water molecules are broken apart and the leaf gives off the oxygen from these molecules. This oxygen, when returned to the air, is used by all living things.

The light energy then works with chemicals in the leaf, such as chlorophyll, to join the hydrogen with carbon dioxide gas. In this way, sugar is made.





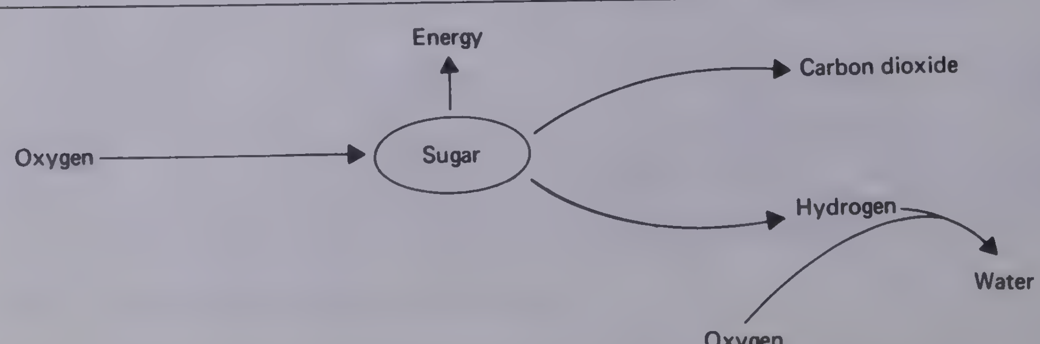


Some plants combine the sugar molecules to form starch. It takes energy to combine the molecules. Starch and sugar are like a ball you have taken to the top of the stairs. They have stored energy.

The second part of the model is concerned with *releasing energy*.

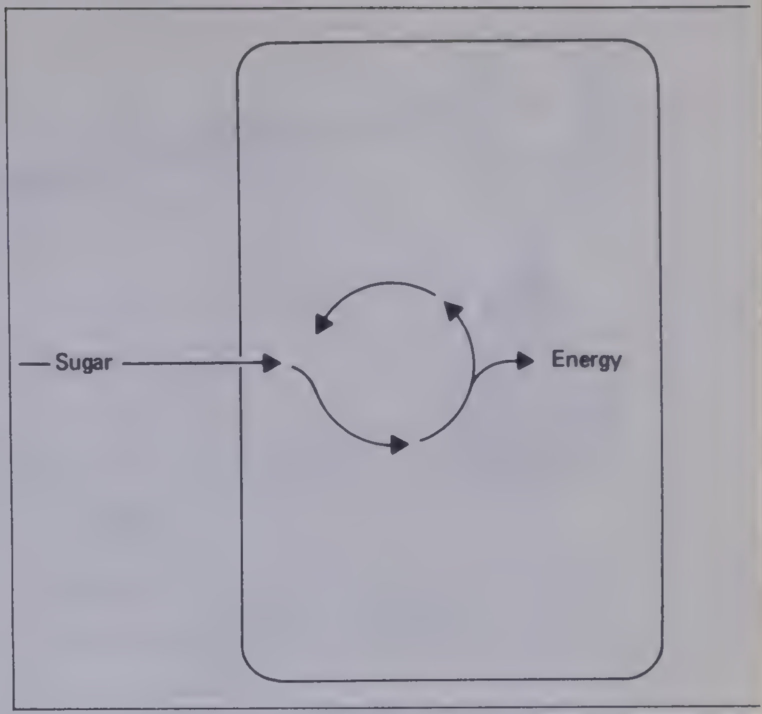
Oxygen is needed to break down starch and sugar molecules. The process is like a fire. If you keep fanning the flames, the fire will burn until all the fuel is burned up. It's the same with the sugar and starch. As long as the cells get a supply of oxygen, the sugar will be broken apart and energy will be released—until all the sugar or starch is burned up.

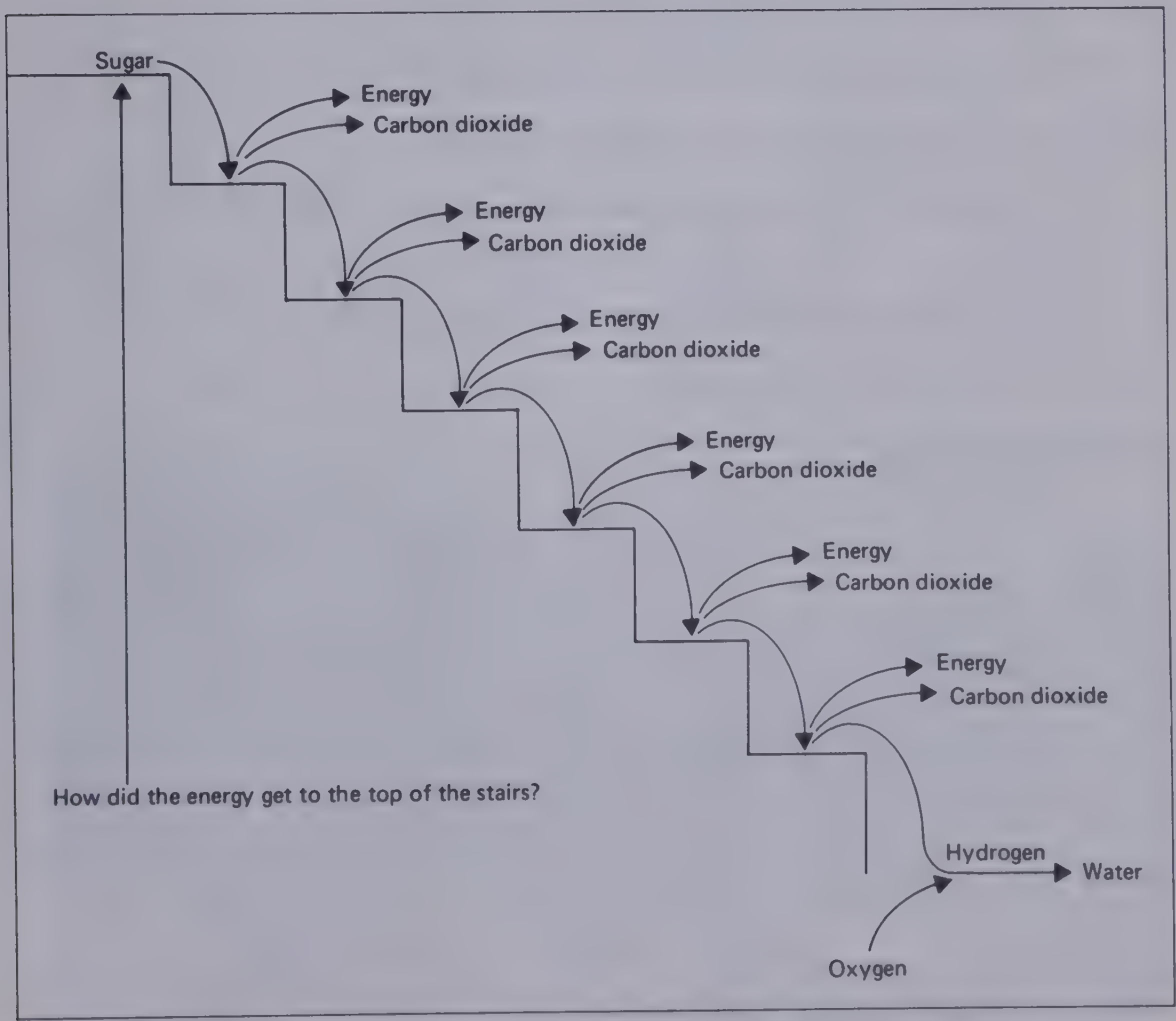
When sugar is broken apart, its carbon atoms join with oxygen to form carbon dioxide. The plant returns carbon dioxide to the air, just as you do when you exhale. Hydrogen atoms also combine with the oxygen to form water. Do you exhale any water? Exhale on the chalkboard. What do you see? This is how plants and animals return water to the air.

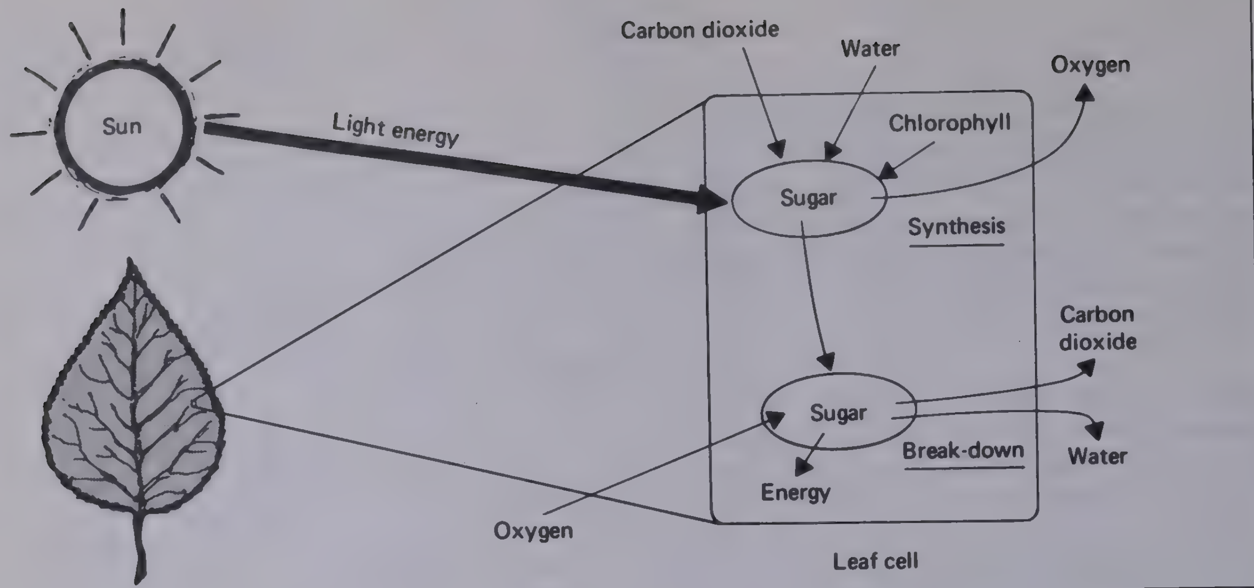


Plant and animal cells release energy in slow, short bursts. This energy must also be changed until it is in a form that can be used by the body cells for staying alive and for work. It's like coming to school with new, unsharpened pencils. They must be changed to a form you can use.

When the sugar is all burned up, carbon dioxide, water, and the energy used for work are left. The entire process goes downhill. If you run out of sugar, you're like the ball that bounces down a flight of stairs. It is out of energy when it sits at the bottom of the stairs. If you want the ball to bounce again, you must spend energy to carry it back up the stairs. You are no different; so keep eating!







Our model is summarized in the diagram. In conclusion:

10. Where does all of the energy for life come from, directly or indirectly?

11. What gas is necessary for plants to build up food?

12. What other substances are necessary for the build-up of food?

13. What gas is needed to release the energy stored in foods?

14. What must happen to the large molecules of food, such as sugar, before energy can be released?

15. If life is to continue, what must broken down foods release?

Using your answers to “13,” “14,” and “15,” complete the Concept Summary.

CONCEPT SUMMARY.

Investigation 7

A City Full of Nature

There have been two major themes running through the last six investigations. The first theme concerns the interaction of plants with their environment. Plants cannot survive alone. They are dependent upon many things in the environment.

The second theme has been the need of all living things for energy. Obtaining energy is not a simple matter. Again, living things must interact with each other and with their environment to obtain energy.

You might say all living things depend on each other and on their environment. What does all this mean? Let's take a look at a city environment.

A. THE CITY IS ALIVE

Wherever we find man, we are almost certain to find dogs. In a wild state and under the best possible conditions, a square mile can support a pack of ten dogs.

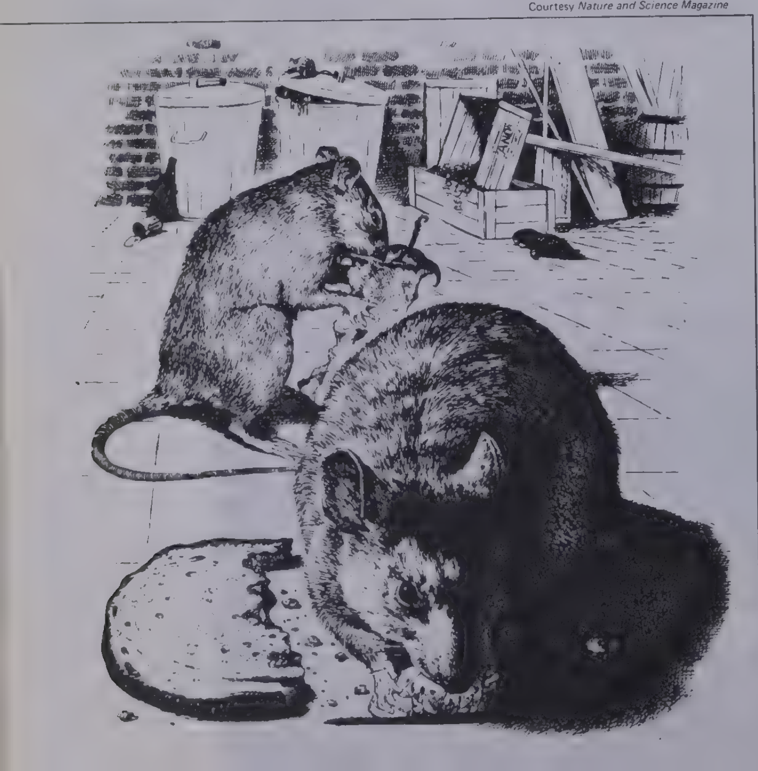
Within an area the size of New York City, about 350 square miles, we might expect to find a maximum population of about 3,500 dogs. Living in New York City, however, are not 3,500, not 35,000, but over 500,000 dogs. If life can only exist where energy is present, how can the city support 500,000 dogs?

In addition to the large number of dogs, there is a tremendous number of rats in city areas. It is estimated that there are a few million rats in New York City.

Rats rarely live in family houses or apartment buildings. They prefer warehouses, sewers, and subway tunnels. They enter houses only when they are hungry and food is short.

Some rats grow to a length of eighteen inches and weigh as much as two pounds. Rats need a great deal of food. Where do they get their energy from?

Courtesy *Nature and Science Magazine*



Foxes, opossums, bats, squirrels, owls, raccoons, and armadillos have also been found in cities. A list of city animals could stretch on and on. This is what you will be doing in this investigation—seeing how many kinds of living things you can find in different areas.

B. A POPULATION OF FLEAS?

The word *population* is not limited to people. When you ask about the population of New York City, you must specify what kind of life you are talking about. If you are talking about people, the population is over eight million. If you are talking about dogs, it is over 500,000.

When you talk about a population, you must think about several things. For example, what kind of living things are you talking about, where are they living, and how many are there?

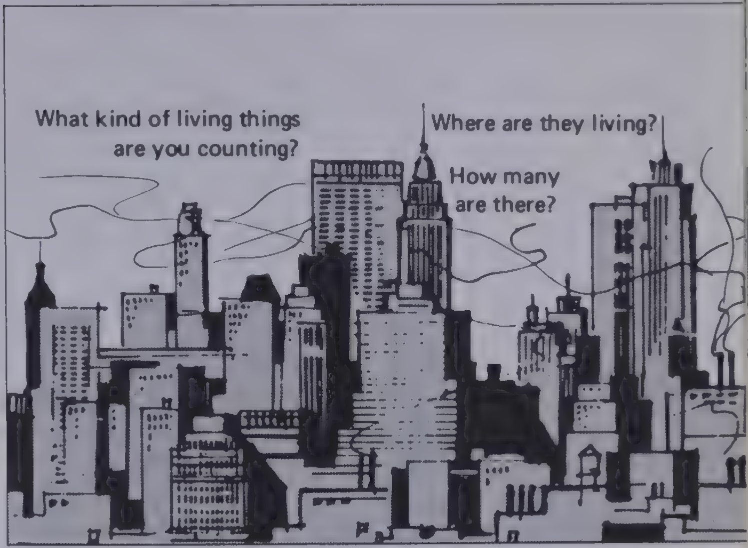
If someone gave you a dog and said, "What is the population of fleas?"–

1. What would you count?

2. What area would you count?

If someone asked, "What is the population of trees?"–

3. What three things would you want to know?



What Is a Population?

Dogs, cats, rats, and mice are usually loners. They may pair off for a short time to mate. Then they go their separate ways, constantly searching for energy to stay alive. But not all populations are made up of loners. Some kinds of living things live together in groups.

C. AN ORGANIZED POPULATION

Over 300 different kinds of birds can be found in New York City. Three very successful populations are the pigeon, the English sparrow, and the starling. The pigeon has probably been the most successful bird in adapting to city life.

4. A bird that is too shy and afraid of people could not live in a city. Why?

5. A bird that is too tame and trusting could not possibly survive in a city either. Why?

6. Look at your answers to "4" and "5." Explain why the pigeon is so successful in a city.

Pigeons are sociable birds that hardly ever live alone. A flock of 10-50 pigeons can live in an area of about three or four blocks. Each flock has its favorite places for feeding and drinking. They keep a daily schedule as rigid as a working man. At eight o'clock they may head for the old lady who leaves crumbs on the windowsill. At nine o'clock they may go to the bakery; at noon, the park; and at two o'clock the back of a restaurant.

Pigeons are like bees, termites, ants, and people in that their population lives together in some organized manner. An organized population is called a *society*.

D. WHAT IS A COMMUNITY?

You live in a community. Rabbits, pine trees, grass, rats, earthworms, and pigeons live in communities, too. What is a community?

The best way to find out is to go out and look at one. The materials and equipment that you need will depend on the areas available for study.

What you have to do is very simple. Go to an area where life appears to be present. Mark off an area, then count and identify, in general, all the forms of life you can find. Here are some suggested places:

A lawn: An area one meter square will be big enough. Get down on your hands and knees and note all the different kinds of grasses, weeds, insects, and worms.

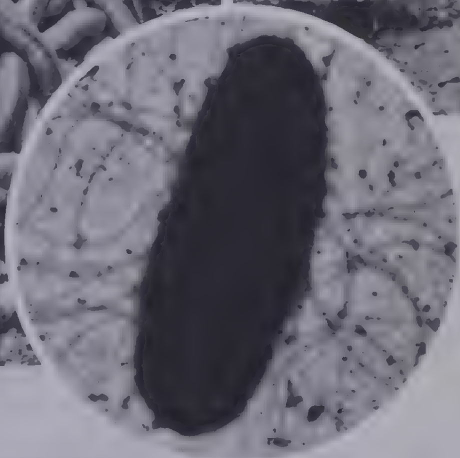
Between Buildings: Is there life in the space between buildings? You may be surprised to find many kinds of living things.

Anita Sabarese from dpi

Franklynn Peterson from Black Star

Canadian Consulate General

USDA Photo



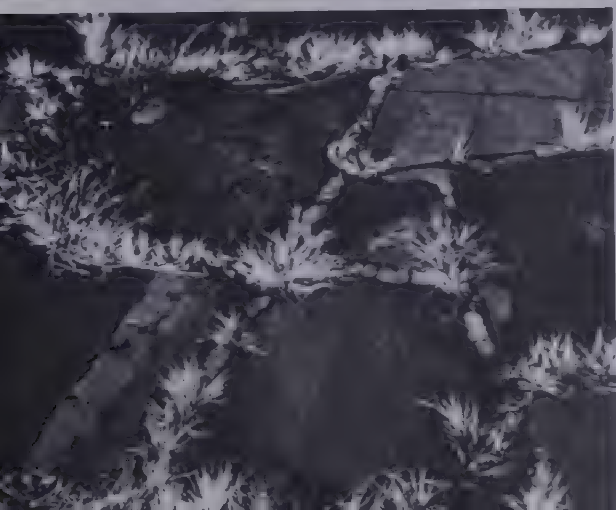
Drs. A.W. Hofer & R.F. Baker and the *Journal of Bacteriology*

An Inch of Soil: What you call dirt may be a thriving community of life. (If you didn't do it before, you may want to try Idea 2, Investigation 2, now.)

Sidewalk or Pavement: Find a sidewalk or pavement with cracks. Are there plants growing up out of it?

A Log: Is there life on a log, under a log, and inside a log? Could a log have a community full of life, like an apartment house?

Seashore: Study a square meter of seashore and you may be surprised with your findings.



John R. Clawson from National Audubon Society

Gordon Smith from National Audubon Society

Playground: You don't have to go out to a forest or even a city park. Find a weed patch in a playing field.

These are just some examples. There are more obvious places you can study, such as an orchard, a forest, a pond, and a field. Astronauts have gone to the moon to see if there is a community there.

E. HAPPINESS IS A PEACEFUL COMMUNITY

Carefully study the site you have chosen. Collect your data as accurately as you would for any other experiment. Here are some things you should look for:

a. Date and time: Will you want to return to this place at a different time?

b. Location: What is the surrounding area like?

c. Size: What is the exact size of the area examined?

d. Coverage: Of all the living things found, are there more of any one kind?

e. Identification: Give the living things general names, like trees, shrubs, herbs, birds, or spiders. You can take a sample of each specimen and give each a letter (*A*, *B*, *C*, etc.).

f. Map of the area: Draw a map showing the location of each form of life.

Look at your data and answer these questions:

7. How many forms of life did you find?

8. Did each form of life live in an area by itself? Explain.

9. Did you find any evidence of organisms helping each other? Explain.

10. Did you find any evidence of organisms living off other organisms? Explain.

11. Name or describe the populations you found.

12. Name or describe the societies you found.

You have just observed and studied a collection of populations and societies living together in the same environment. In order for a community to survive, the individuals, populations, and societies in it must depend on one another.

13. What is meant by depending on one another?

14. What must the individuals, populations, and societies in a community seek constantly if they are to survive?

15. What do you call a unit of individuals, populations, and societies living in mutual dependence?

CONCEPT SUMMARY.

Investigation 8

A Mold Can Save Your Life

We think nothing of stopping for a hamburger when we're hungry. We get a battery if the flashlight doesn't work. And we know that a car won't run without gasoline.

Energy in its various forms comes so easily to us. But energy doesn't come so easily for many people and for many living things. Hunger is the world's greatest problem.

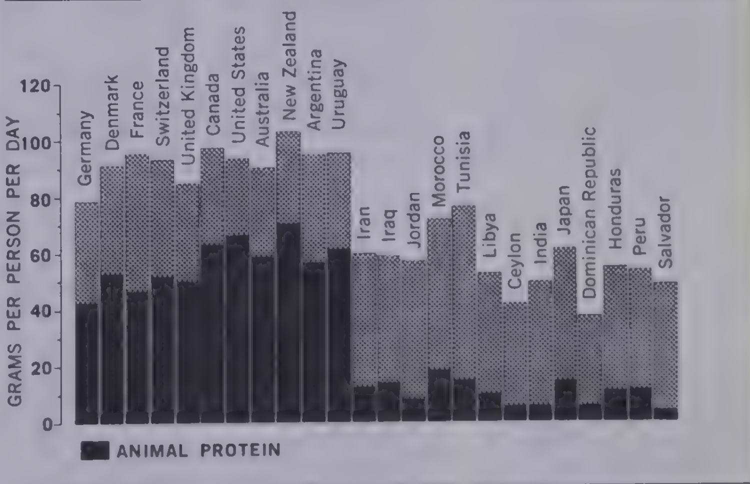
Would you believe that you can fill your stomach and still starve? It is estimated that 350 million children suffer from protein starvation. These children suffer from body defects, mental retardation, or early death.

George Holton from Photo Researchers

An adult needs 14 percent protein in his food; children and pregnant or nursing women need from 16 to 20 percent. Graph 1 illustrates one of the world's greatest problems. But don't let the graph mislead you. Despite the high percentage of protein eaten by Americans, thousands still go hungry.

GRAPH NO. 1

DAILY PROTEIN INTAKE IN VARIOUS COUNTRIES



Chris Reeberg from dpi

If life is to continue, energy must be available. Is there enough energy for all the living things in the world?

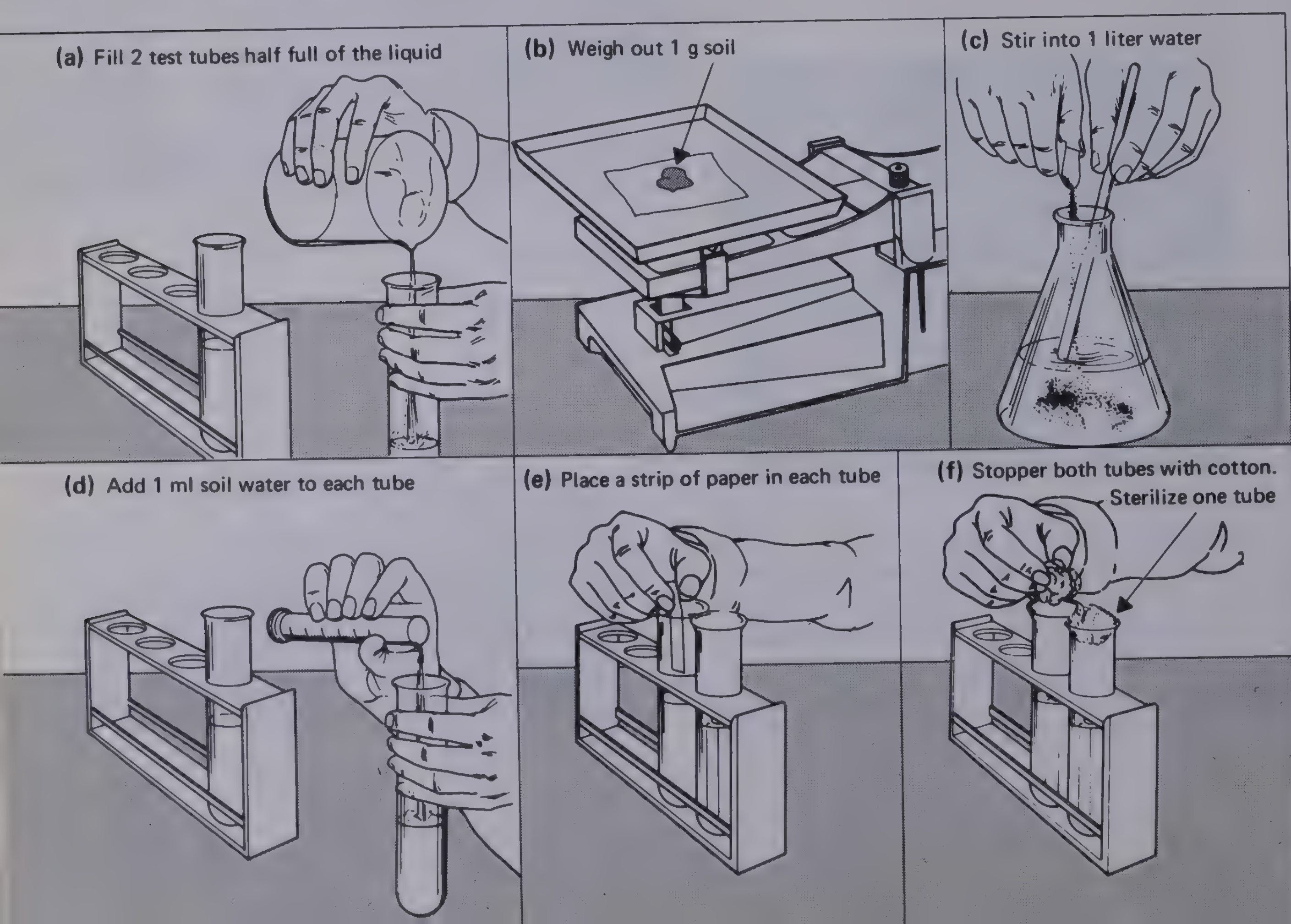
A. WHERE DO THEY GO?

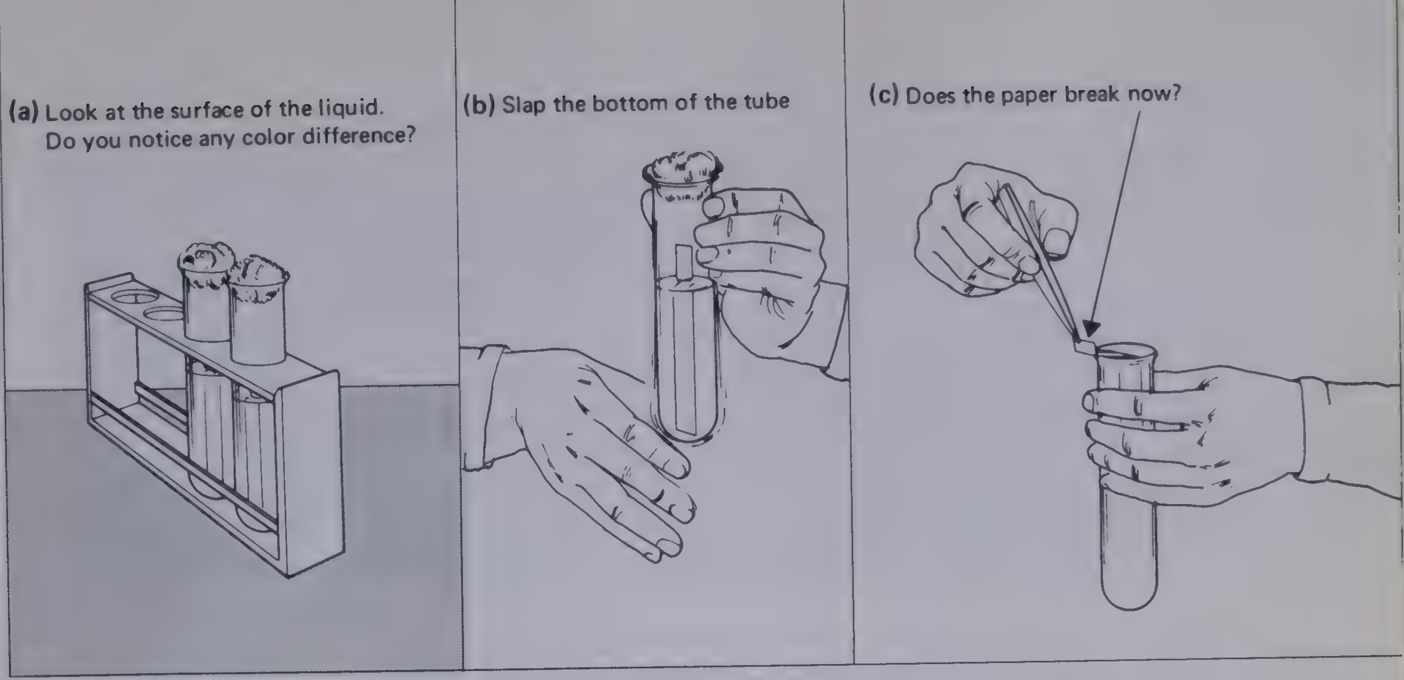
Have you ever wondered what happens to all the leaves, needles, and twigs that fall to the ground? If they were to collect year after year, the streets and the forests would be a pile of litter. But the litter seems to disappear mysteriously. Where does it all go?

To find out, we can do a simple experiment. Since paper is made from trees, we can use strips of paper for our test.

Prepare two test tubes as shown. Using the liquid supplied by your teacher, fill each test tube half full.

Next, weigh out 1 g of garden soil and stir it into 1 liter of water. Add 1 ml of this liquid to each of the two test tubes.





Place a six-inch strip of paper into each tube, and stopper each tube with a cotton plug. Sterilize one tube in a pressure cooker.

Keep both tubes together in a warm place for 1-2 weeks. After 10-14 days, carefully make two observations:

1. Look at the paper at the surface of the liquid. Do you notice any color change?

2. Hold the tube in one hand and gently slap the bottom of the tube with the other hand. Does the paper break? If the paper does not break, gently pull it with your forceps. Does the paper break now?

3. Which tube was the control?

4. Why was one tube sterilized?

5. How would you explain any color change at the surface of the liquid?

6. Did one strip of paper break more easily than the other? Which one?

7. Did anything happen to the strip of paper in the control tube? Explain.

8. Although you can't see them, what do you think are probably in one of the tubes?

9. Why do you think the change is taking place at the surface of the liquid? Hint: What is above the water? What must be present before energy is released?

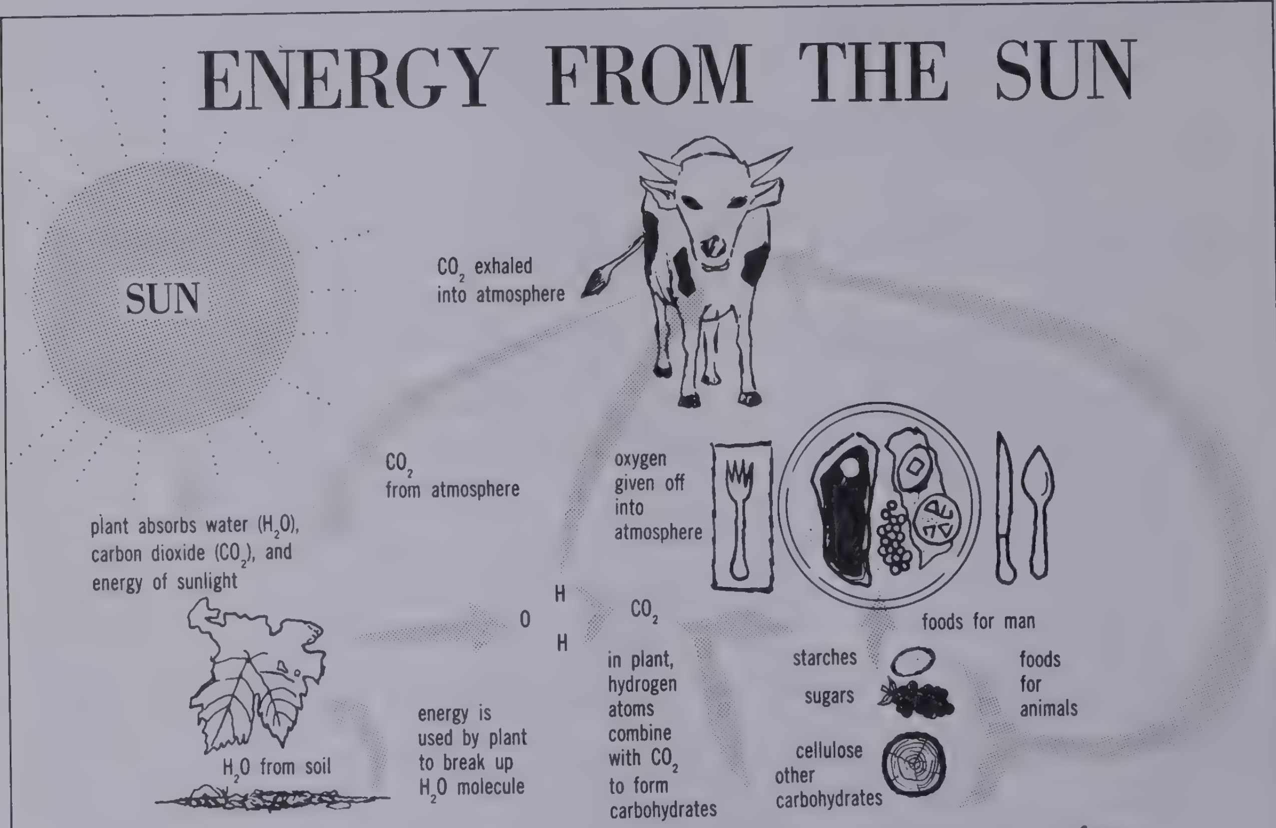
10. What do you think caused the strip of paper to break easily?

11. What do you think happens to most of the leaves that fall to the ground?

As you learned earlier in this Idea, plants are an important part of our diet. They are also important to animals. All living things are part of a *food* or *energy chain.* Carbon dioxide is at the base of this food supply and energy. No carbon dioxide, no plants. No plants, no food. No food, no energy. No energy, no life! It is as simple as that.

CO_2 → Grass → Deer → Mountain lion

For life to continue, living things must put carbon dioxide back into the air. This process is summarized in the diagram. But the food or energy chain does not end with animals. What do you think happens to the animals? What are new sources of carbon dioxide?



Where does the oxygen in plant products such as carbohydrates come from, water or carbon dioxide?

(Carbon dioxide. When water molecules are broken up the oxygen released enters the atmosphere.)

Some carbon dioxide is returned to the air by burning such fuels as coal, oil, gasoline, and wood. These fuels are the fossil remains of plants and animals that died millions of years ago.

Environmental Protection Administration

A City Sewage Treatment Plant

There is another way that carbon dioxide is returned to the air. In fact, most carbon dioxide is returned to the air this way. Something causes leaves, twigs, and needles to break down just as the paper strips did in your experiment. Animals that die are broken down in the same way. This process of breaking down is called *decomposition.*

A sewage plant needs certain organisms to decompose the waste materials. Farmers need the same organisms to make food for animals. The dairy industry needs them to make cheese. We refrigerate, can, salt, and dry foods to prevent these same organisms from causing decomposition.

New York State Department of Commerce

12. What organisms are responsible for decomposition? Answer by completing the sentence in Diagram 1 of your data sheet.

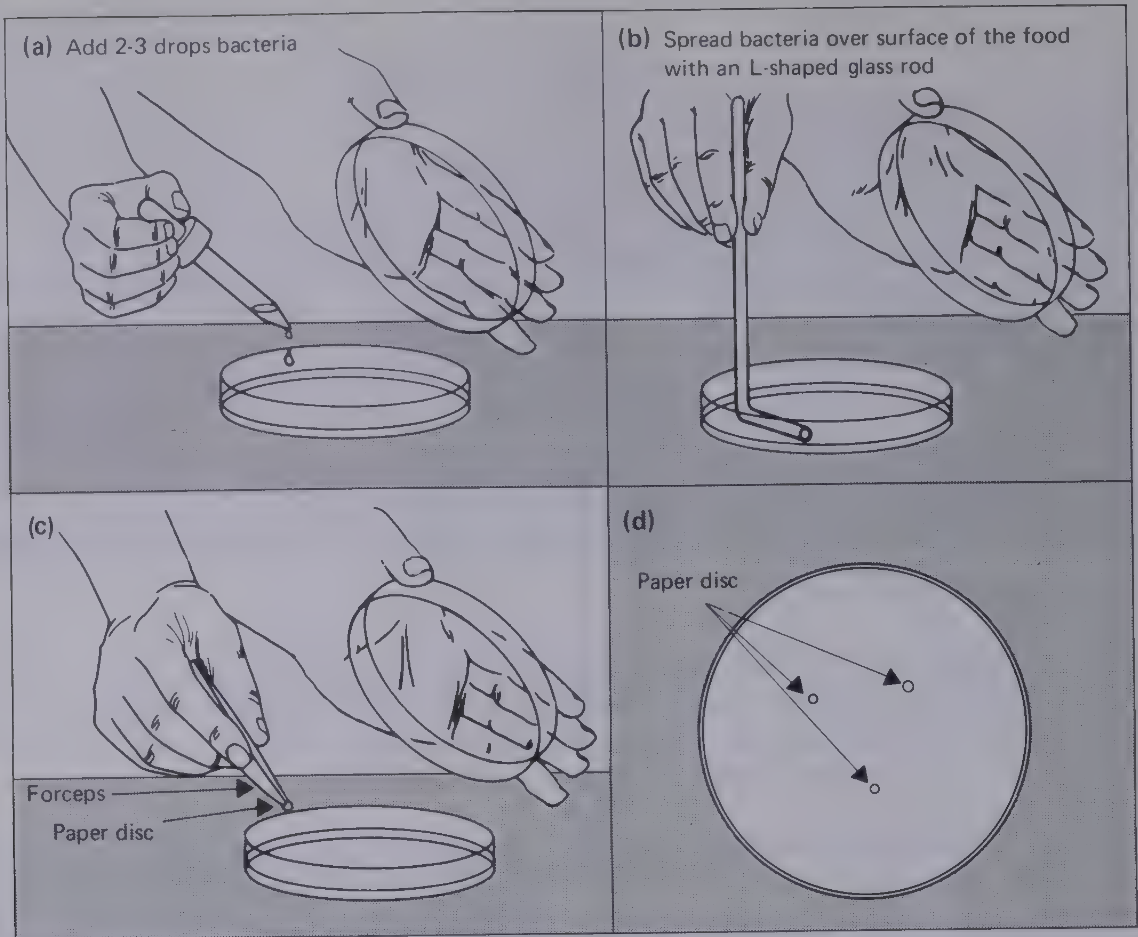
B. DON'T COME NEAR ME

Those who do the eating sometimes get eaten in return. This is all part of the food or energy chain.

You will be given a Petri dish containing food material needed to grow bacteria. Do not open the dish until you are ready to begin. The dish and its contents have been sterilized.

Read all directions from steps a-f carefully before beginning.

Kraft Foods

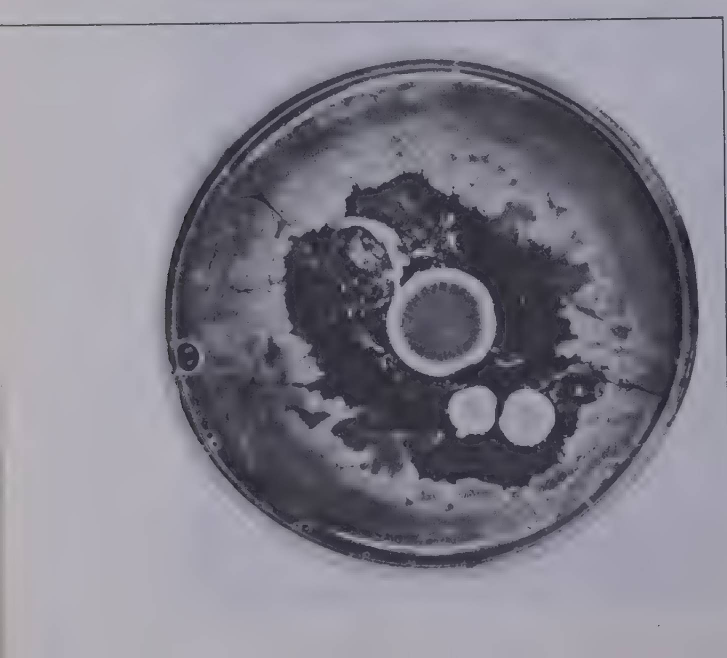


a. Carefully lift one edge of the Petri dish and add 2-3 drops of a liquid containing bacteria.

b. Sterilize an L-shaped glass rod by dipping it in alcohol or heating over a flame.

c. Carefully lift one edge of the Petri dish cover. Spread the liquid over the top of the food, as shown in the drawing.

Penicillium Mold



Merck & Co., Inc.

d. Close the Petri dish and return the glass rod to the container of alcohol.

You will next be given some substances that are made by some other organisms, called molds. A mold is shown in the photograph.

Some molds were grown in a laboratory. The substances in the cells were then taken out. You will be given a paper disc that has been soaked in this cellular material.

e. Use sterilized forceps to place the paper disc in the Petri dish.

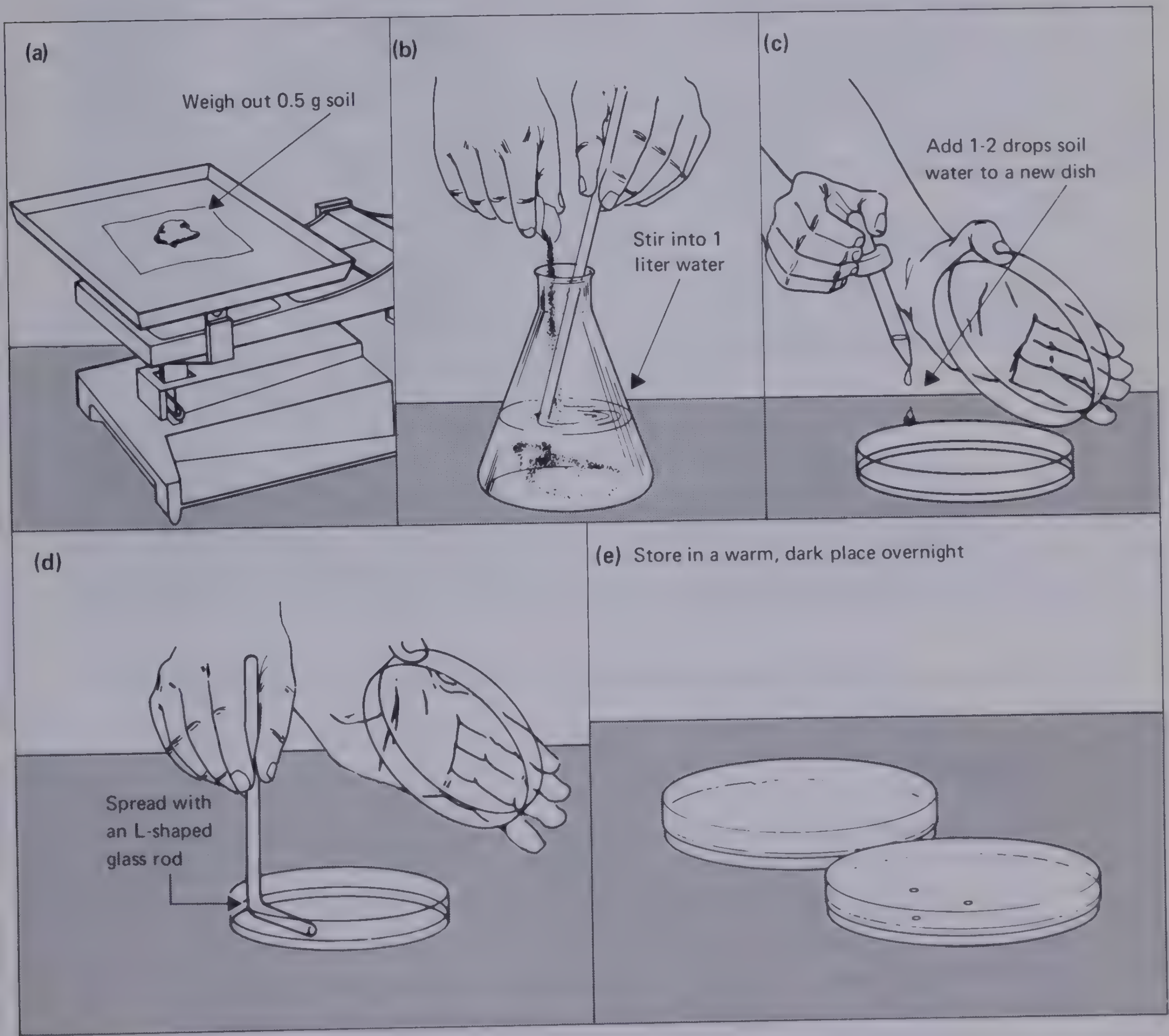
If your teacher has more of these discs containing different substances, put them in the Petri dish, too. Keep the discs separated from each other.

f. Place the entire dish in a warm, dark place overnight.

C. WHAT'S IN MY DISH?

You will be given another dish containing the food needed to grow bacteria. Weigh out 0.5 g of rich garden soil and mix it into 1 liter of water. Add 1-2 drops of this liquid to the dish and spread with the L-shaped glass rod. Refer to steps b-d above.

Place this dish also in a warm, dark place overnight.



Examine both dishes the next day. In space *a* of your data sheet, make a simple sketch of what you see in the dish with the paper discs. In space *b* of your data sheet, make a sketch of what you see in the dish with the soil water.

13. Is there bacterial growth all over both dishes? If not, where is bacterial growth absent?

14. Why do you think the bacteria are absent in these areas?

Not all scientific discoveries are made in an exact manner. Some great discoveries have been made by accident—but it takes a prepared mind and a sharp eye to spot the accidental discovery.

In 1929, Alexander Fleming made one of these accidental discoveries. He was looking at some Petri dishes when he noticed that one did not have bacteria growing all over the dish. The dish he observed was similar to the ones you have just observed. It had a clear area around a spot of growth.

Examining the growth in the center of the clear area, he found that it was a mold. This mold was very similar to the green mold found on oranges. He had not been careful in his experiment and some mold in the air had fallen into his dishes of bacteria. The name of this mold is *Penicillium.*

If you were Fleming, what would you predict? Here are two different kinds of life growing in a dish—bacteria and a mold.

15. What are both kinds of life competing for?

Wide World Photos

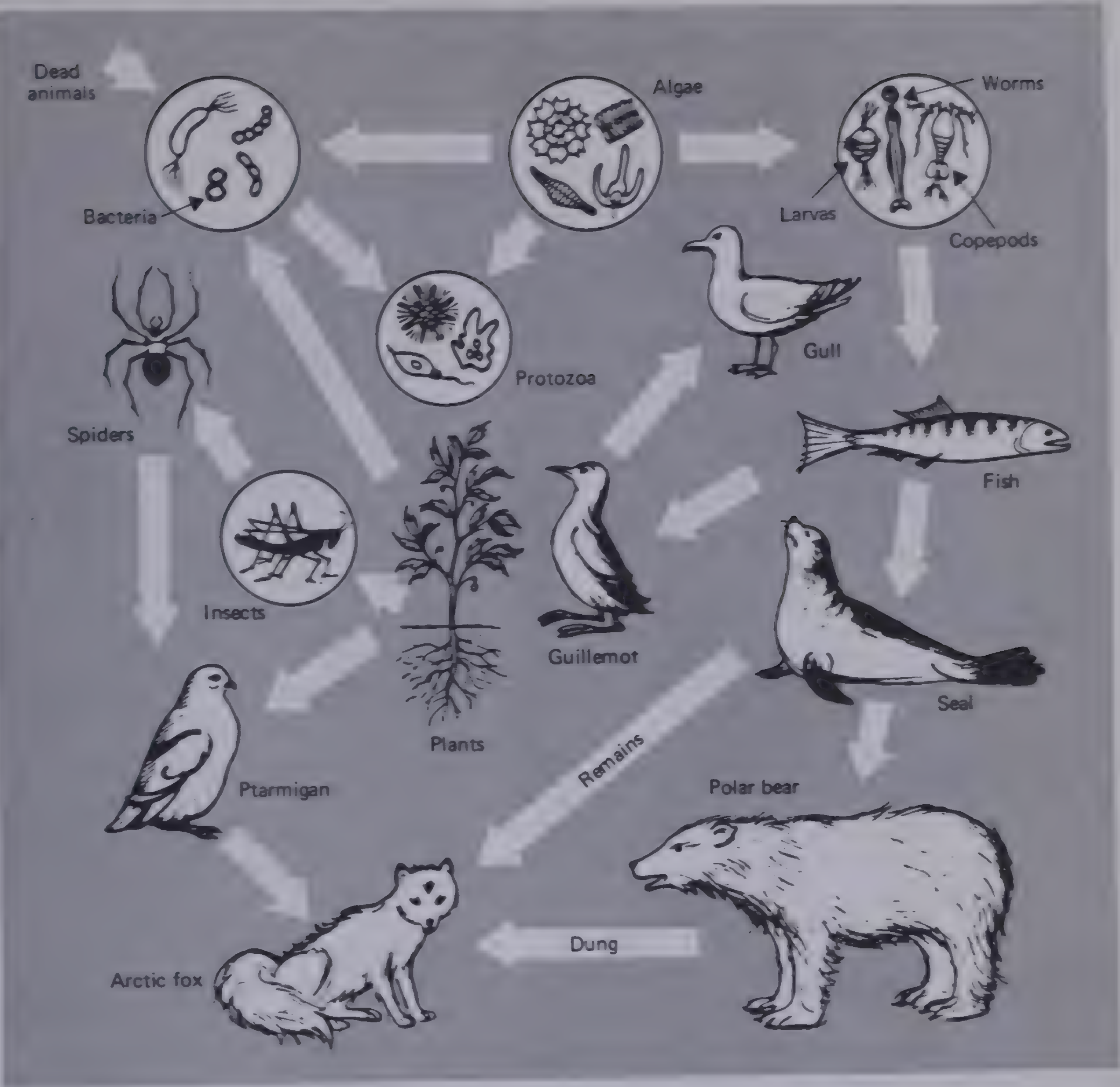
Sir Alexander Fleming

16. What do you think the mold is producing to prevent the bacteria from growing close to it?

D. A FOOD WEB

You have learned that a community is an organized group of populations. For instance, in a community on an Arctic island, there may be populations of insects, algae, fishes, birds, seals, and bears. These populations are related to each other in a very complicated *food* or *energy web.*

A food web is a series of food or energy chains knit together. This is illustrated in the diagram. The arrows are read "eaten by." For instance, fishes are eaten by seals.



You learned in part A that bacteria obtain their energy by decomposition.

17. According to the diagram, what do the bacteria decompose to obtain energy?

18. Algae are microscopic green plants. Where do the algae obtain their energy?

19. Who are the bacteria and algae eaten by?

The relationship of the dead animals, plants, algae, and protozoa represents a food or energy chain. There are many other food or energy chains shown in the diagram. Each food chain, however, does not exist alone. It is related to the others in a larger food or energy web.

20. Who else eats the algae besides the bacteria and the protozoa?

21. Who eats the animals that eat the algae?

22. If the fishes are eaten by the seals, who eats the seals?

23. What does the Arctic fox eat?

24. Who eats whom in the food chain involving the ptarmigan, insects, spiders, and plants?

25. What are all of the organisms in a food web constantly competing for?

26. What is a food web?

CONCEPT SUMMARY.

Investigation 9

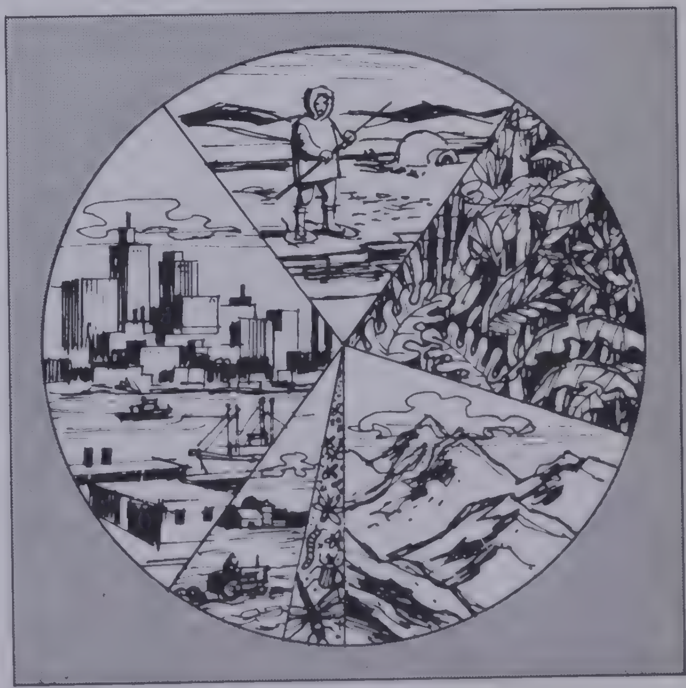
It's a Small World

Each year, throughout the world, fifty million babies are born. They must be fed, housed, and clothed.

It has been estimated that the population of the earth will double in forty years, from three billion in 1960 to six billion in 2000. Over half of the people are now undernourished. As the population grows and underdeveloped nations raise their standards of living, will we have enough food and energy for everyone?

GRAPH NO. 1

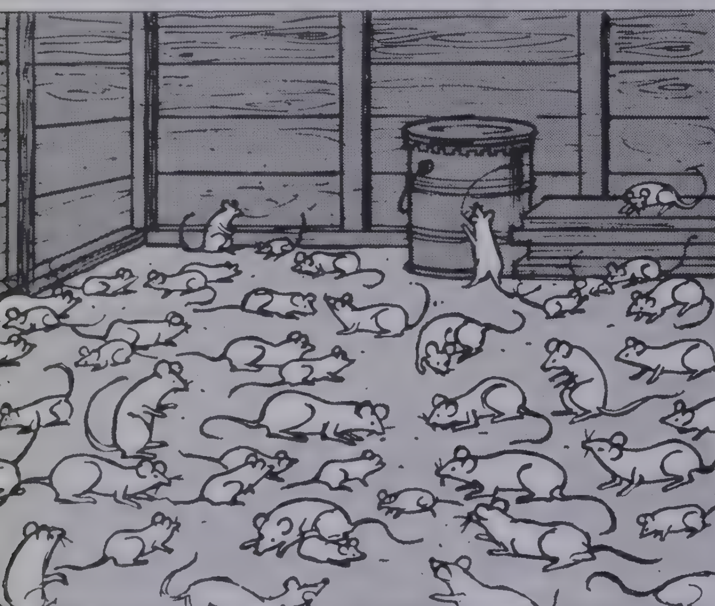
WHERE CAN WE GROW OUR FOOD?



At present, more than one-half of the earth cannot be used to grow food. For example, some places are too cold, while others are too hot. Some are very hilly, and others are too wet or dry.

We farm on only one-tenth of the earth and lose some of this each year to construction projects. In addition, insects destroy large amounts of the food grown. There is truly a constant struggle for energy.

To help us understand the constant mutual dependence among living things and between living things and their surroundings, we can examine an aquarium, a pile of forest litter, or a bottle of pond water.



A. NOT A CREATURE WAS STIRRING

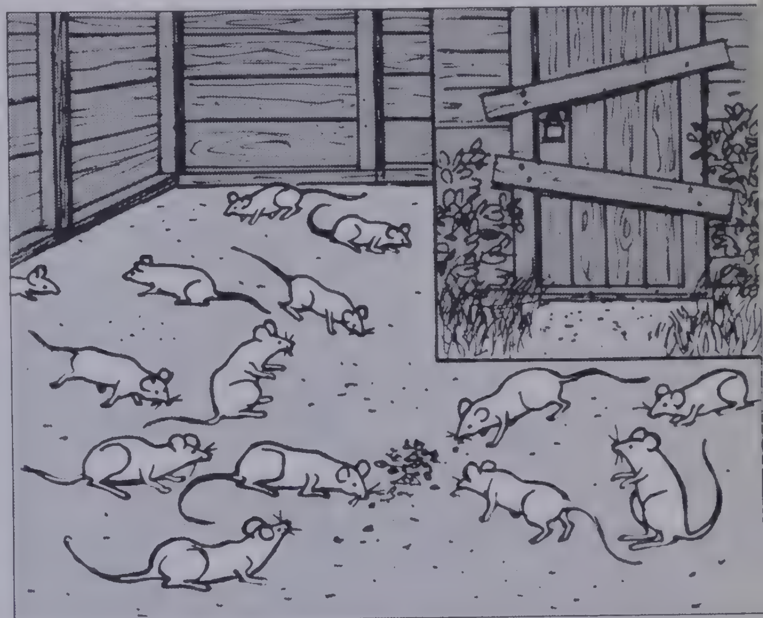
Mice are very cautious and intelligent animals. When all the two-legged creatures stop stirring, mice come out in search of food. Some years ago at the University of Wisconsin, Professor John Emlen and his students studied the population of mice in an old building.

Each day they carefully weighed out exactly 250 g of food and left it where the mice would find it. This was more than enough for the few mice in the building. The population grew. Soon the mice were eating all the daily food supply.

From time to time, mice were captured and the population size estimated. The observers discovered that the size of the population became stabilized. When the daily food supply was exhausted, some mice left the building to search for food elsewhere. A balanced condition was reached. Mice were leaving the building at the rate at which new mice were born.

What would happen if the building were sealed and escape made impossible or if an unlimited amount of food were supplied? There are no definite answers to these questions.

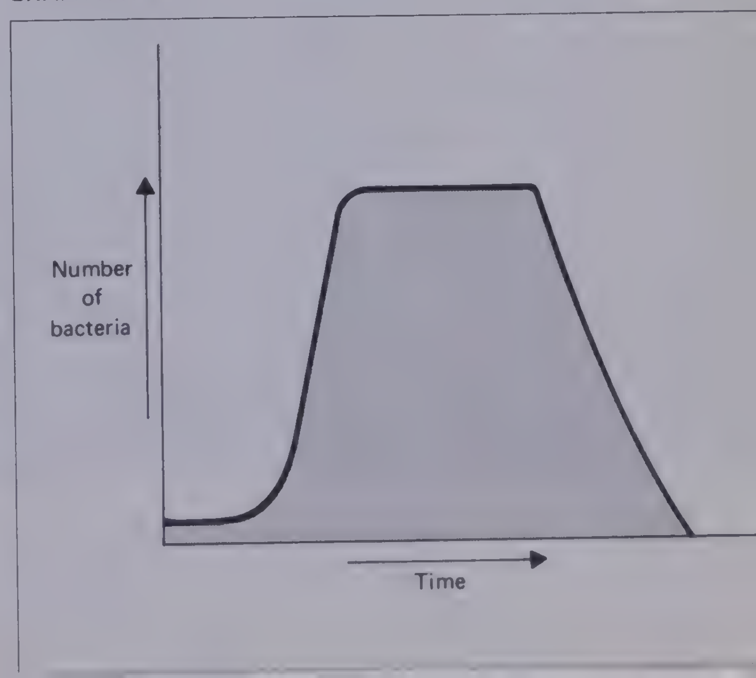
In one experiment, as the population increased, chasing, fighting, and cannibalism increased greatly. Females stopped taking care of their young and almost all the babies died. The high death rate kept the population at a stabilized level.



In another experiment, as the population increased, the females had far fewer babies. The low birth rate kept the population stabilized.

Does this mean that a population will always rise to a certain point and then reach a stabilized level? You did an experiment in Idea 3, Investigation 2, which should help you answer this question. Graph 2 shows what happens to a population of bacteria.

GRAPH NO. 2



1. If the information in the graph holds true for other living things, what will happen to the population of mice pictured on page 266?

2. What do you predict would happen if a population of cats were placed in the sealed building with the population of mice?

3. What do you predict would happen if a mold such as *Penicillium* were placed into a tube of growing bacteria?

B. NO MAN IS AN ISLAND

No one lives alone. Mice do not live alone. Neither do bacteria. We are all part of a mutually dependent community. Do changes ever take place in a mutually dependent community? Let's see.

You will be given a plastic flask. Fill this with pond or aquarium water supplied by your teacher. Replace the screw cap and do not open the flask again for the next 4-6 weeks.

To examine the contents, place the flask on the stage of a microscope. Use the low power lens. Describe or draw what you see. In addition, indicate if the population of each of the organisms is:

abundant	– all over the flask
frequent	– quite a few
occasional	– once in a while
rare	– very few

Do not use the high power lens. The aim is not to identify or name any of the organisms.

Design your own table in space *a* of your data sheet to record your observations.

C. A WHOLE WORLD IN A BOTTLE

You have just looked at a community over a period of time. Use your observations to answer the following questions.

4. Did you see the same organisms every time? Explain.

5. Did the kind of organisms and their frequency remain the same during the entire time you observed the contents of the flask? Explain.

6. What kind of organisms were most abundant when you first started your observations?

7. What kind of organisms were most abundant after 2-3 weeks?

8. What kind of organisms were most abundant at the end of your observation period?

9. During which weeks were the most changes in the population observed?

10. Did the community inside the flask change much during the last two weeks of your observation? Explain.

11. The flask was closed during the entire period of observation. Where was the energy coming from?

12. What are some factors that may have caused the community to change?

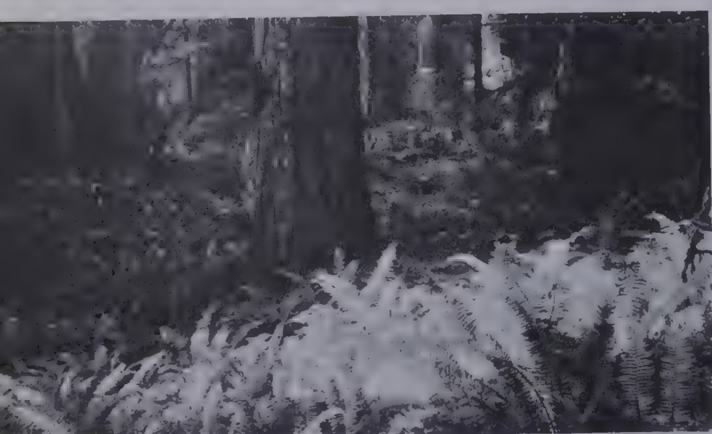
D. CAN YOU BALANCE A TREE?

A forest that has not been disturbed by man is hard to find. There are a few in wilderness areas, national forests, and protected in preserves next to some cities.

General Motors

U. S. Forest Service

Photo by David Swanlund, courtesy of Save the Redwoods League



U.S. Forest Service

If you study some of these forests you will find tall trees that need much sunlight and smaller trees that can survive in less sunlight. Mosses and other small plants on the forest floor are all able to exist with very little light.

When a forest has remained the same for a long time, we say that the community has reached a *climax*. Trees are the main form of life. But a climax forest wasn't always there. Changes took place over hundreds and thousands of years.

For example, a lake may have been in the area at one time. As the conditions on the earth changed, the lake dried out. Coarse grasses grew in the sand..

As the grasses died and decomposed, they added organic matter to the ground. Different plants appeared.

These were followed by small trees, then taller trees, and then even taller trees.

In this forest the tall trees are the dominant form of life, but they live in harmony with all the other plants of the forest. A climax has been reached and a state of mutual dependence keeps the forest going, year after year.

But you don't have to go to a forest to find a climax community. Other examples of a climax community are shown in the photographs.

A Climax Community in a Balanced Aquarium

John Hughe from National A. Jubon Society

A Climax Community in the Galapagos Islands

Courtesy of the American Museum of Natural History

In this investigation, you have reviewed a number of concepts and discovered a new one.

13. What did all the living things in the flask represent?

14. What are all the living things competing for?

15. What will happen to a community that is starting out new or has an outside influence disturbing it? (Examples might be the introduction of new organisms or a change in environmental conditions.)

16. After a period of time, what will happen to a community?

CONCEPT SUMMARY.

Investigation 10

Beautiful Downtown Burbank

You have come to the last investigation in this Idea. You have learned that:

a. Living things constantly need energy.

b. Plants convert light energy into food energy by a process known as photosynthesis.

c. Living things need oxygen to release the energy stored in food.

d. The same kind of organisms live together in groups called populations.

e. A community is a group of different populations living together.

f. Within the community, there is a constant interaction for energy.

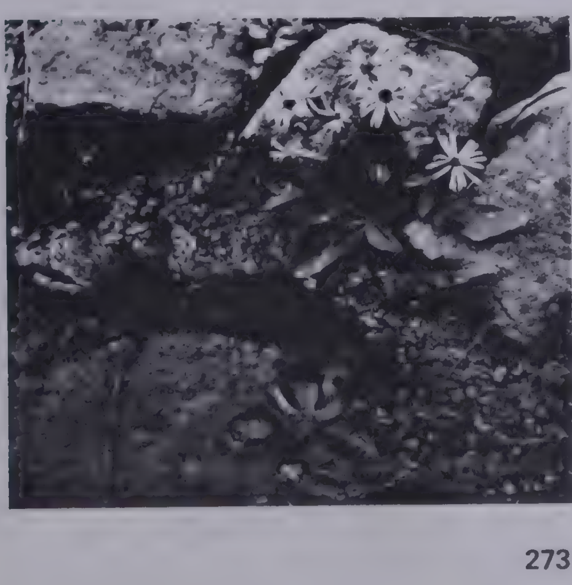
g. In order for the community to remain together, an intricate food web develops as living things compete for the available energy.

h. A succession of the number and kinds of populations in a community can be observed until a climax is established.

When a community reaches its climax, a stable or balanced condition exists. All of the organisms in the community live in mutual dependence. Three climax communities are shown in the photographs.

A Climax Forest

American Forestry Assoc



Wide World Photos

Allan D. Cruickshank from National Audubon Society

Does a climax community ever change? In this investigation we will study the question.

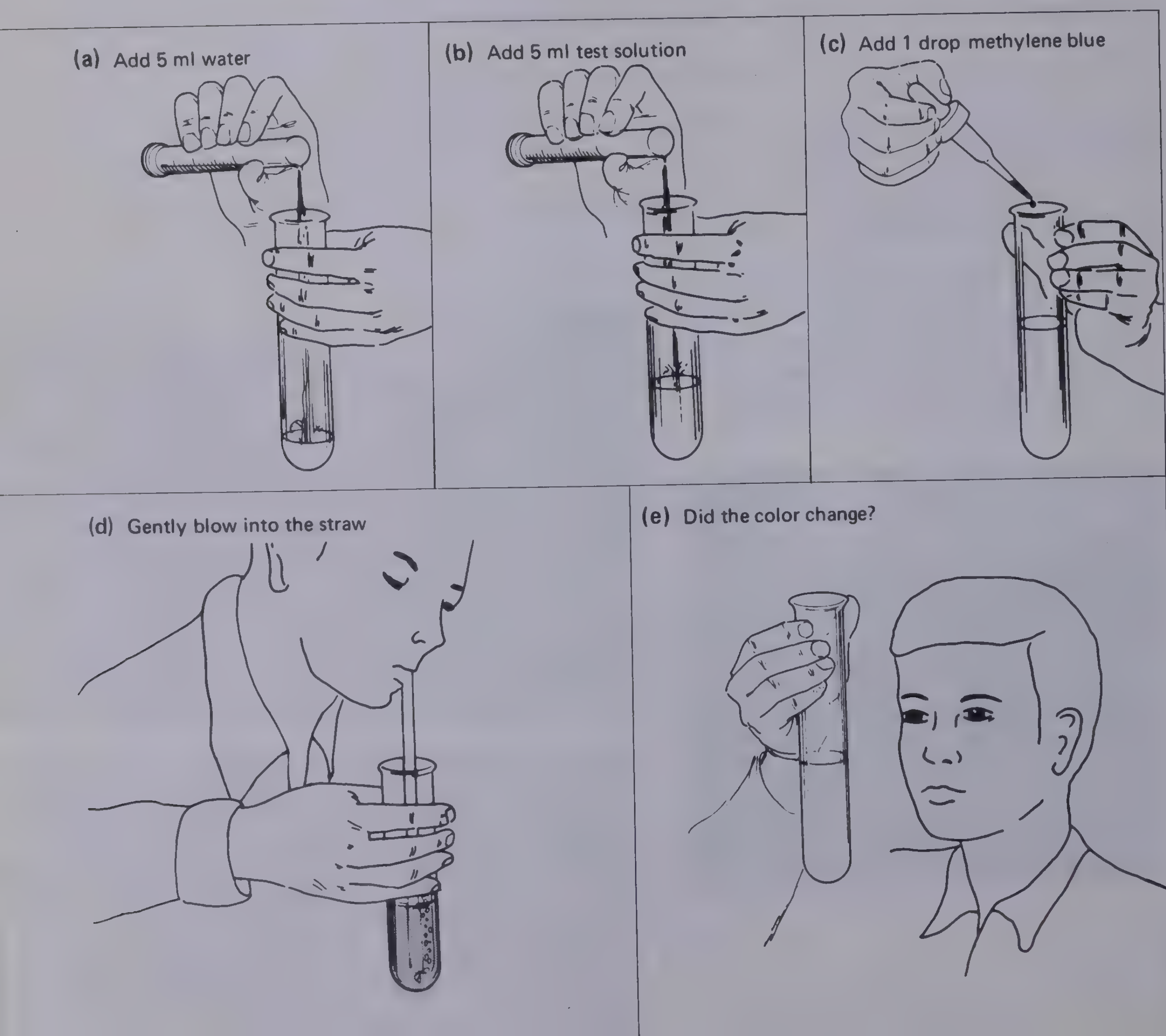
A. HELP, I NEED AIR

In the last investigation, you examined the community of organisms living in a flask of water. Now you will examine the water for oxygen. You know that living things need oxygen. Therefore, the amount of oxygen dissolved in water can affect the presence and success of various organisms.

You will use an indicator called methylene blue to test water for the presence or absence of oxygen.

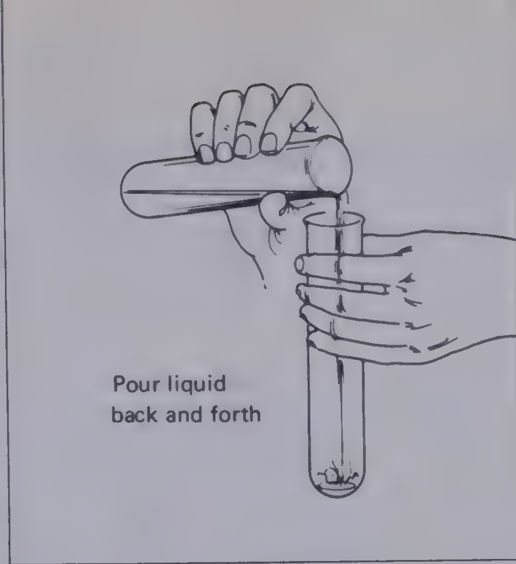
Obtain two test tubes. Place 5 ml of tap water and 5 ml of test solution in one tube. Add 1 drop of methylene blue to the water. Then gently exhale through a straw into the water.

1. What happened to the color of the water when you exhaled into it?



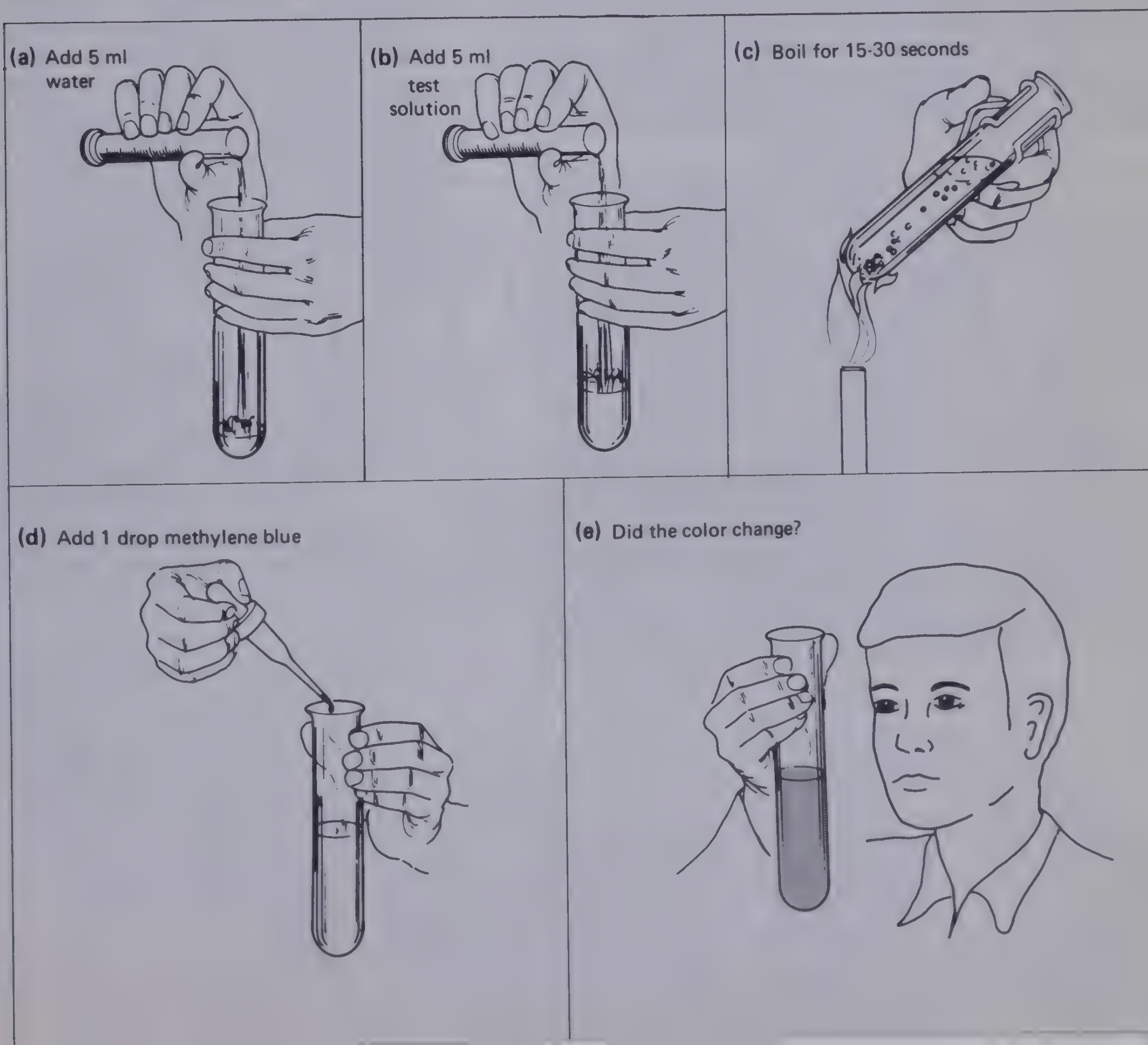
2. An excess of what gas was being exhaled into the water?

Pour the water back and forth between the test tube of water and the empty test tube for a minute. This aerates the water. It has the same effect as bubbling oxygen into an aquarium or the action of waves in the ocean.



3. What happened to the color of the water after oxygen was put back into it?

Add 5 ml of tap water and 5 ml of test solution to another test tube. *Gently* heat the water to boiling. Continue to boil the water for 15-30 seconds. Be careful that the water does not boil out of the tube onto yourself or another student.



Add 1 drop of methylene blue to the boiled water.

4. When methylene blue is added, what color is the boiled water?

5. This color tells you that what gas is missing?

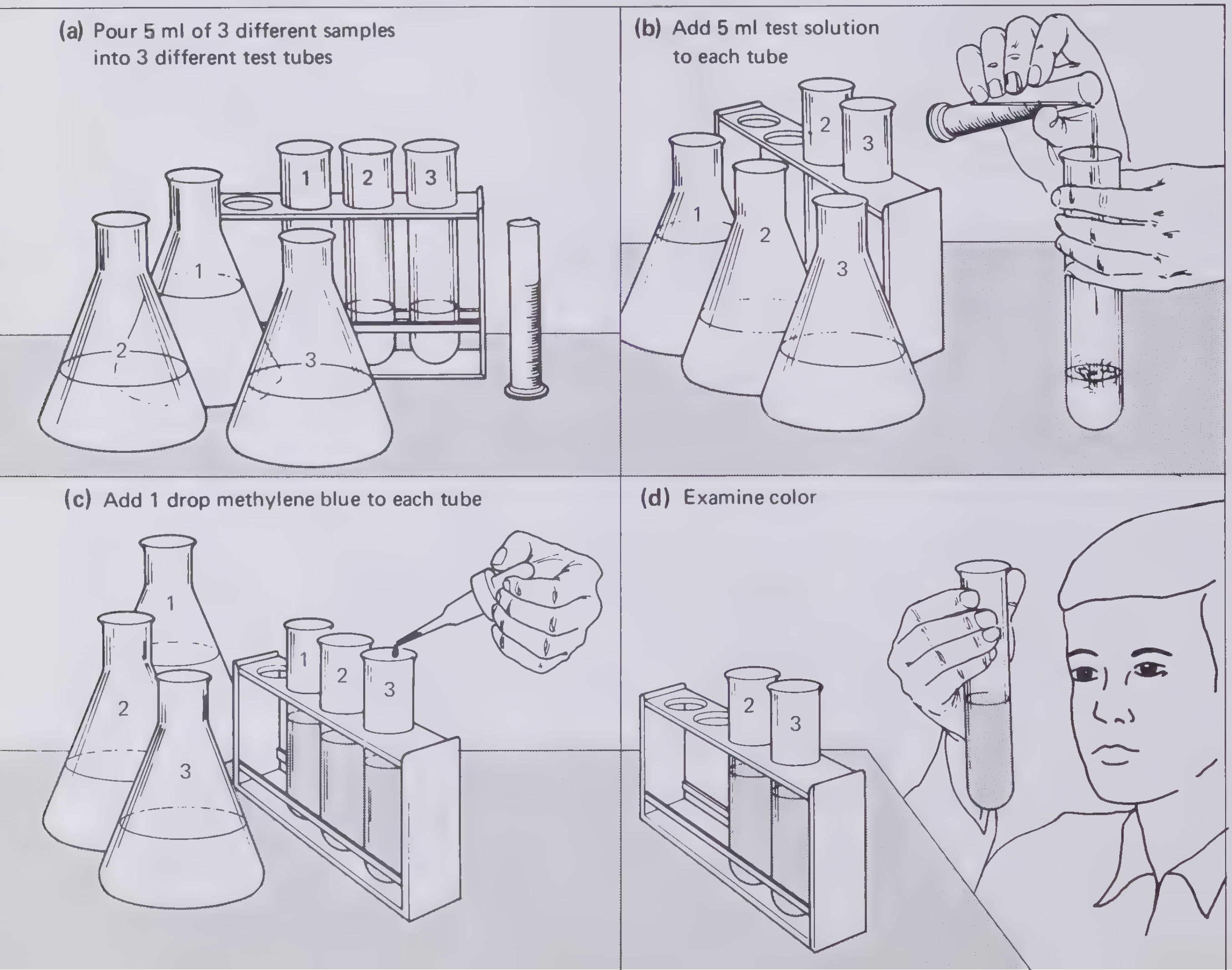
Again, aerate the water by pouring it back and forth between two test tubes for a minute.

6. What happened to the color of the water after oxygen was put back into it?

When water is heated, much of the oxygen boils off. This is why boiled water can taste flat. It lacks oxygen.

Now that you see how methylene blue works in water, let's use it to test some unknown samples of water.

Measure 5 ml of each sample into separate test tubes. Add 5 ml of the test solution to each tube. Give each tube a number. Add 1 drop of methylene blue to each tube. Allow the tubes to stand for at least one minute before reading the color. Record your observations in column two of Table 1 in your data sheet.



(a) Pour 5 ml of 3 different samples into 3 different test tubes

(b) Add 5 ml test solution to each tube

(c) Add 1 drop methylene blue to each tube

(d) Examine color

From your data, determine which samples are polluted and which are not polluted. Record this in column three of Table 1.

Your teacher will tell you the source of the water samples. Write this in column four of Table 1.

7. What gas is lacking in polluted water?

8. How does polluted water affect living things?

Lake Tahoe

B. PLEASE DO NOT FEED

Some lakes like Lake Tahoe in California have stayed clear and maintained a thriving community of living things for centuries. But look at what is happening to Lake Erie.

Lake Erie is one of the Great Lakes. It extends 250 miles and is the shallowest of the five Great Lakes. 18,000 tons of sewage, fertilizers, and chemicals flow into Lake Erie each day! At one time, valuable fish such as pike and whitefish were plentiful. Today, very few valuable fish are caught. What happened?

The death and disappearance of these fish is not because the sewage, fertilizers, and chemicals are poisons. In fact, the presence of these materials in the lake water stimulates the growth of algae. A population explosion takes place!

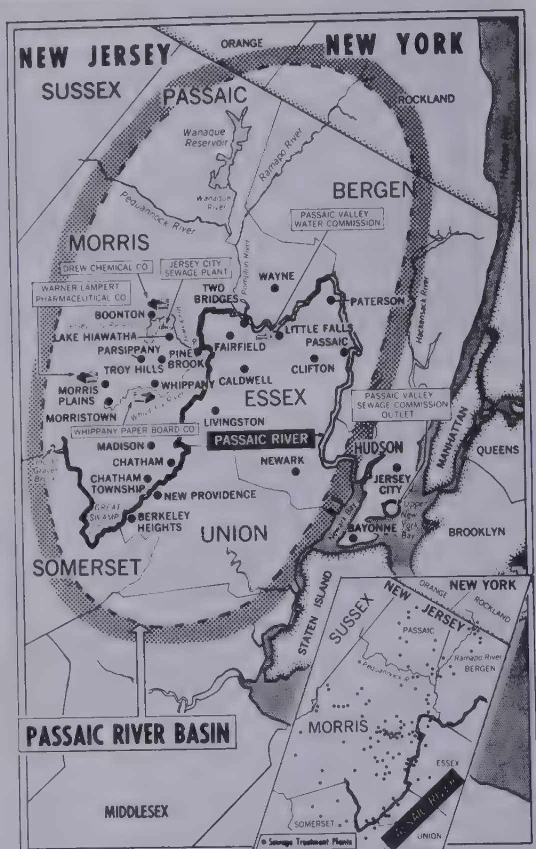
As more living things appear, there are more that will die. More and more bacteria multiply, since there is plenty of food for them. A population explosion of bacteria also occurs.

Cleveland's Cuyahoga River, Which Enters Lake Erie

The balanced condition of the lake is soon upset. The overabundant algae and bacteria use up the oxygen and choke out the other forms of life, such as fish. The waste dumped into the lake, together with the excess algae and bacteria, pollute the lake.

9. Both the fish and the bacteria need a gas dissolved in the water. The gas is __?__

Wide World Photos



Wide World Photos

10. If there is not enough of this gas to meet the needs of both the fish and the bacteria, more individuals of which kind will die first? Explain why.

11. Explain this statement: "Lake Erie is actually dying from too much food."

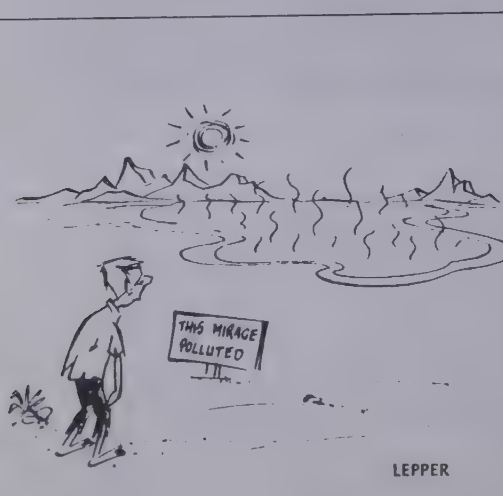
C. THE MURDER OF A RIVER

At the beginning, there is a meadow, wild flowers, a bubbling spring of pure water, a stream, and a red salamander. But it only takes 80 miles for New Jersey's Passaic River to be born and die. It dies from pollution.

Wide World Photos

There are trout at the beginning. But nine miles downstream, at Berkeley Heights, the first sewage plant appears. One hundred forty-nine more sewage plants empty into this river before it ends in Newark Bay. All the way down the river, one sewage plant after another, and one chemical and industrial plant after another, empties its waste products.

At the beginning, a beautiful balanced community. At the end, an ugly collection of polluted water.



Reprinted Courtesy *Parade Magazine*

The Hudson River flows not far from the Passaic River. Pete Seeger wrote the "Hudson River Song," which describes what has happened to the river that flows past New York City.

Pete Seeger

Pete Seeger

MY DIRTY STREAM
by Pete Seeger

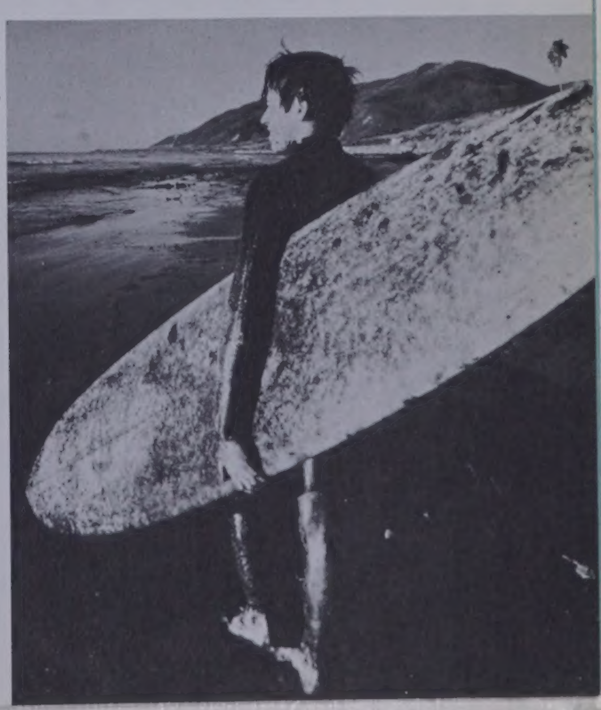
"Sailing down this dirty stream
Still I love it and I'll keep the dream,
That some day though maybe not this year
My Hudson River will once again run clear.
It starts high in the mountains of the north,
Crystal clear and icy trickles forth.
With just a few floating wrappers of chewing gum
Dropped by some hikers to warn of things to come."

"At Glens Falls, five thousand honest hands
Work at the Consolidated Paper Plant
Five million gallons of waste a day—
Why should we do it any other way?
Down the valley one million toilet chains
Find my Hudson so convenient place to drain
Each little city says, 'Who me?
Do you think that sewage plants come free?' "

"In the great ocean they say the water's clear
But I live at Beacon here.
Half way between the mountains and sea
Tacking back and forth, this thought returns to me
Sailing up my dirty stream
Still I love it and I'll dream
That some day though maybe not this year
My Hudson River and my country will run clear."

Remember that climax forest? It was stripped away and it is now an abandoned coal mine.

Here's the seashore you saw previously. It's covered with an oil slick.



Vernon Merritt, *Life* Magazine © Time, Inc.

Results of Strip Mining

Courier-Journal and Louisville Times

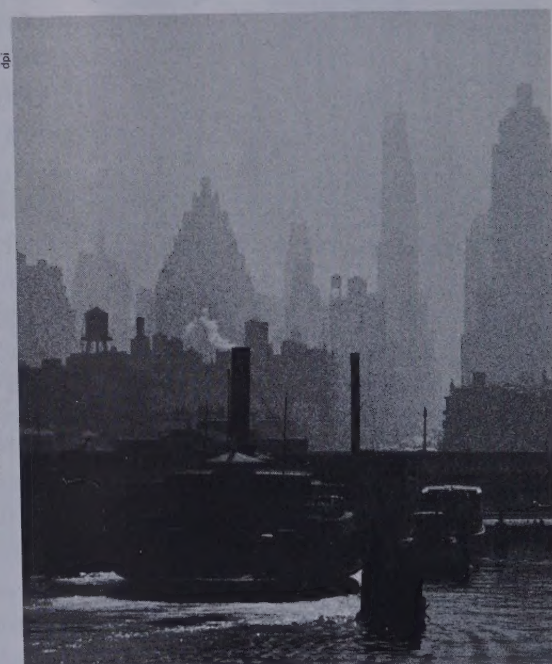
D. SOCK IT TO ME

The word "ecology" was devised in 1869 to represent the relationship between living things and their environment. Ecology is what everybody must start thinking about, if we are to avoid the pollution of our entire planet.

Everything around us is tied together in mutual dependence. The plants help renew our air; the air helps purify our water; the water irrigates the plants. Man cannot master nature. Man must learn to live with nature. Men must work together to insure that we do not upset the environment so much that it cannot be saved.

Fresno County and City Chamber of Commerce

dpi



Will your world have a beautiful downtown or will your world be covered by a cloud of pollution?

If a community, living in mutual dependence, is upset, what may happen to it? That is the question for you to answer in the concept summary. That is also a question for us all to consider seriously!

CONCEPT SUMMARY.

NBC Photo

"Ver-r-y Interesting"

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